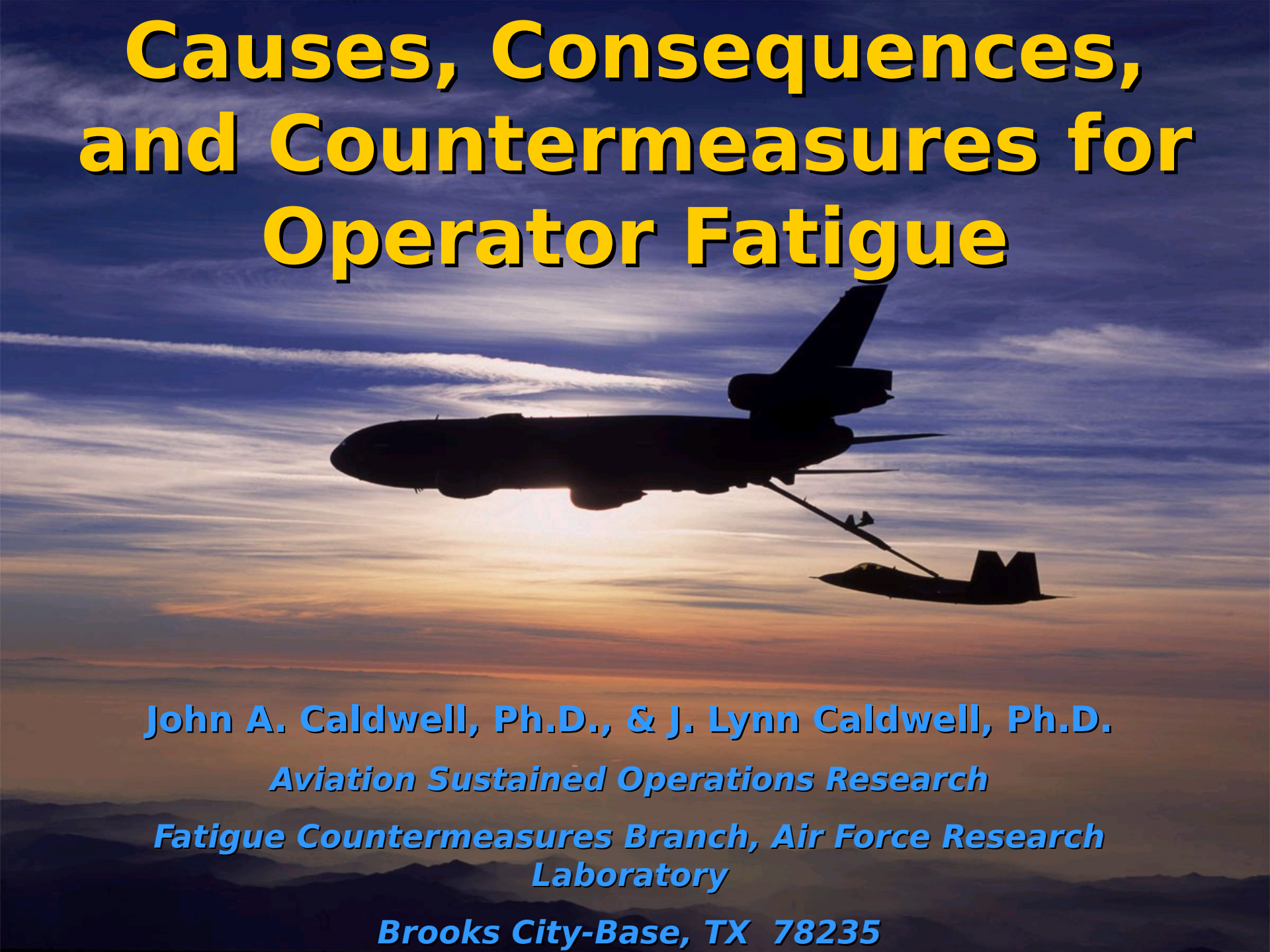
Causes, Consequences, and Countermeasures for Operator Fatigue



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Definition of fatigue

- Fatigue is the state of tiredness associated with prolonged work, and/or prolonged wakefulness.
- Sleep deprivation and circadian factors are major components of the fatigue equation.
- Fatigue is an internal state that affects both physiological activity and subjective feelings.
- The terms “fatigue” and “sleepiness” are often used interchangeably.

Measuring fatigue

- Unfortunately, there are no biochemical markers for fatigue.
- Thus, there isn’t a breathalyzer for fatigue/sleepiness.
- Often we must rely on subjective impressions of ourselves or others to know how fatigued we are.

Good to Go

Unsafe at any speed!!

Fatigue is a big problem

- The fact that fatigue cannot be directly measured doesn't mean it isn't a serious concern.
- In fact, a recent consensus statement issued by an international panel of scientists concluded that:

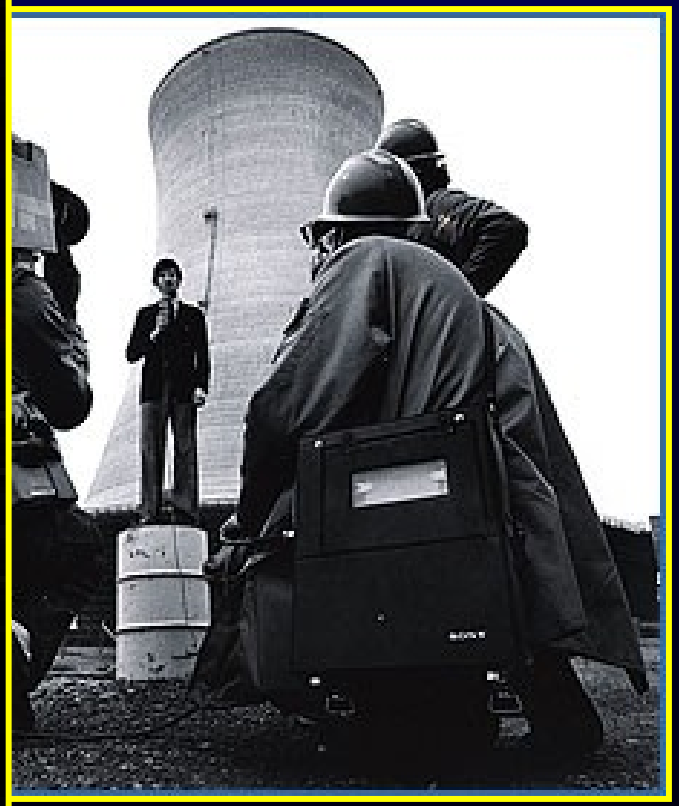
> ***Fatigue is "the largest identifiable and preventable cause of accidents in transport operations (between 15-20% of all accidents), surpassing that of alcohol or drug related incidents in all modes of transportation. Official statistics often underestimate this contribution."***

- Sleep loss and circadian disruptions often results in dire consequences.

Grounding of the Exxon Valdez

Third mate misses light and buoy marking shore and crashes into reef after hours of duty without sleep. 11 million barrels of oil spilled.

Near Meltdown at Three Mile Island



Night shift misdiagnoses problems with emergency feedwater, heating reactor to 4,300 degrees. Radioactive material vented to atmosphere.

Explosion of the Shuttle Challenger

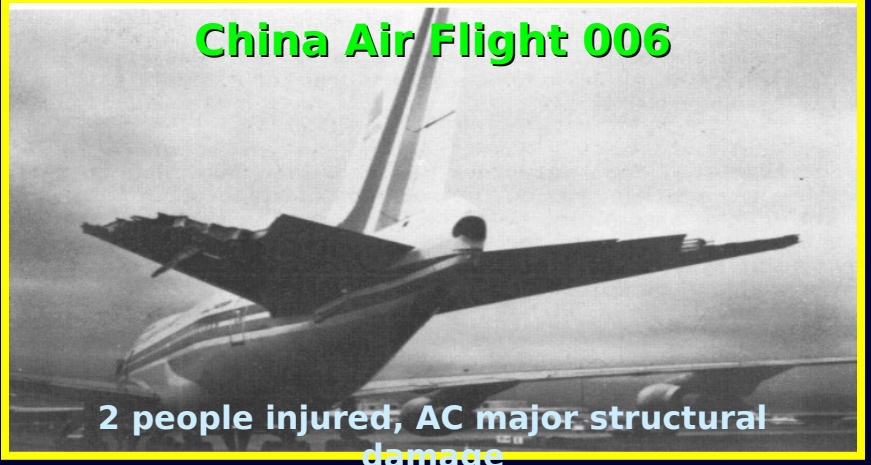
NASA makes decision to launch in the cold despite conference with Morton Thiokol—decision makers had been awake more than 24 hours. Space shuttle destroyed, crew lost, NASA suffers huge PR fallout

Single Vehicle Car Crashes

Driver fell asleep going home from work. Just a small part of the 100,000 crashes and 1,500 fatalities on the highways last year.

Aircraft Accidents

China Air Flight 006



2 people injured, AC major structural damage

Korean Air Flight 801

228 killed, AC destroyed

American Flight 1420

11 killed, AC destroyed

FedEx Flight 1478

3 severely injured, AC destroyed

…and others…

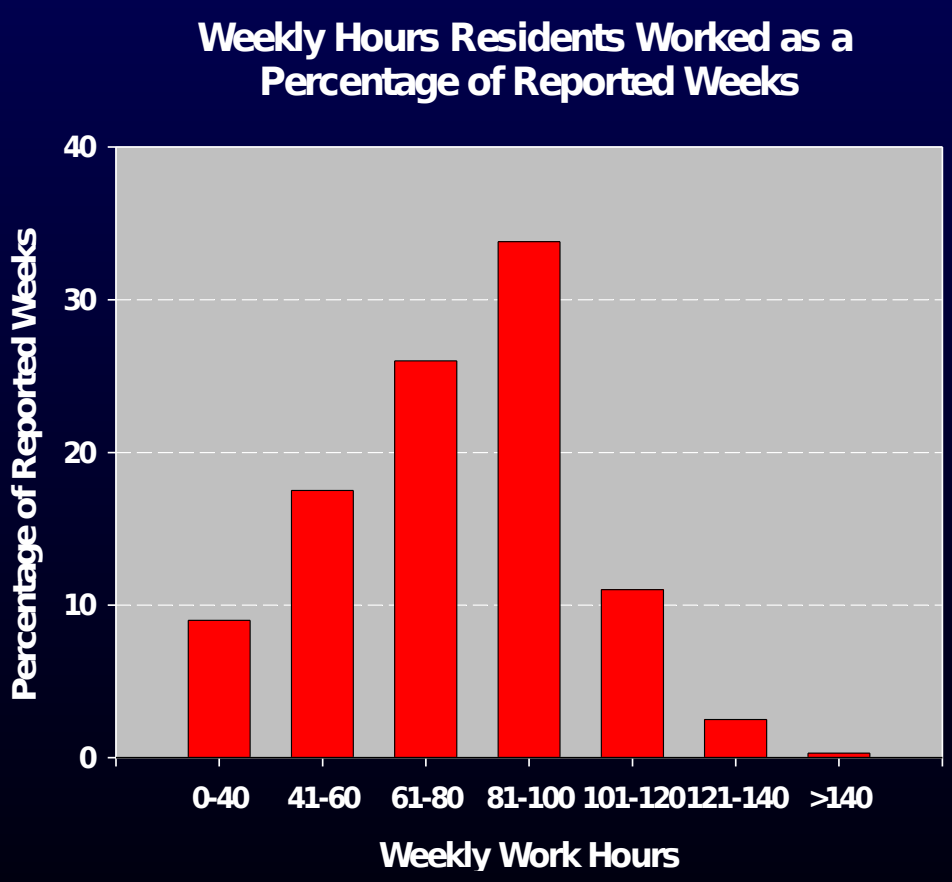
Fatigue touches many sectors

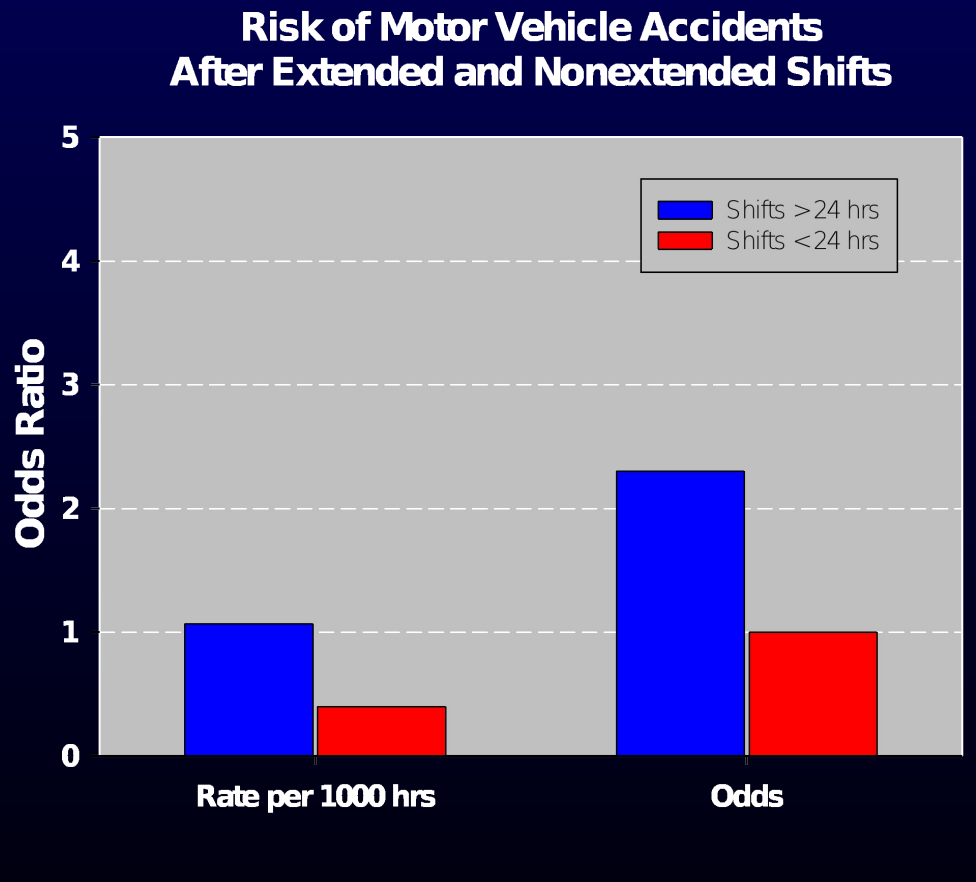
- **Fatigue is responsible for 4-8 percent of commercial and military aviation incidents and accidents.**
- **NHTSA attributes 100,000 highway accidents, 1,500 fatalities, 71,000 injuries, and $12.5 billion a year to fatigue.**
  - In 55% of crashes, the drivers were under 26 yrs old (mostly male)
  - The risk is 6 times higher for shift workers
  - The risk is 40% higher for those working more than 60 hrs per week
  - Also, anyone who is sleep deprived, driving long distances, at night, without sufficient breaks (especially on boring roads), and especially under the influence of drugs or alcohol is an accident waiting to happen!
- **The National Sleep Foundation estimates sleepy personnel cost employers $18 billion annually in lost productivity.**

Fatigue threatens quality medical care too

- Forty-one percent of residents blame fatigue for their most serious mistake (in one-third of these, the patient died).
- In one study, 37% of first-year ob/gyn residents slept less than an hour per night while on call.
- Work periods routinely stretch to 36 hrs straight (more than what it takes to produce decrements equal to 0.1 BAC).
- Residents' sleepiness levels (measured by MSLTs) have been found greater than those associated with clinical sleep disorders!

…and watch out if you're on the road when these docs are headed home





From: Barger, Cade, Ayas, et al. (2005). Extended work shifts and the risk of motor vehicle crashes among interns. The New England Journal of Medicine. 352(2):125-134.

Why is fatigue a growing problem throughout society?

- Since 1883, the electric light changed night into day, extending work time.
- This led to reduced sleep time (in the past century Americans have reduced their sleep time by 20%, down to less than 7 hrs a night).
- In the 1950's the advent of night vision technology made the battlefield a 24/7 operation.
- Over 25 million people now routinely engage in shift work (and many are in the military).
- Transportation improvements have enabled the crossing of 1 time zone *per hour* rather than 1 time zone *per day*.

Extended work, shift work, and jet lag have exacerbated the fatigue problem

- Longer duty periods and shortened sleep lead to sleep deprivation.
- Shift changes and rapid time-zone transitions lead to circadian disruptions.

Sleep deprivation

+

Circadian factors

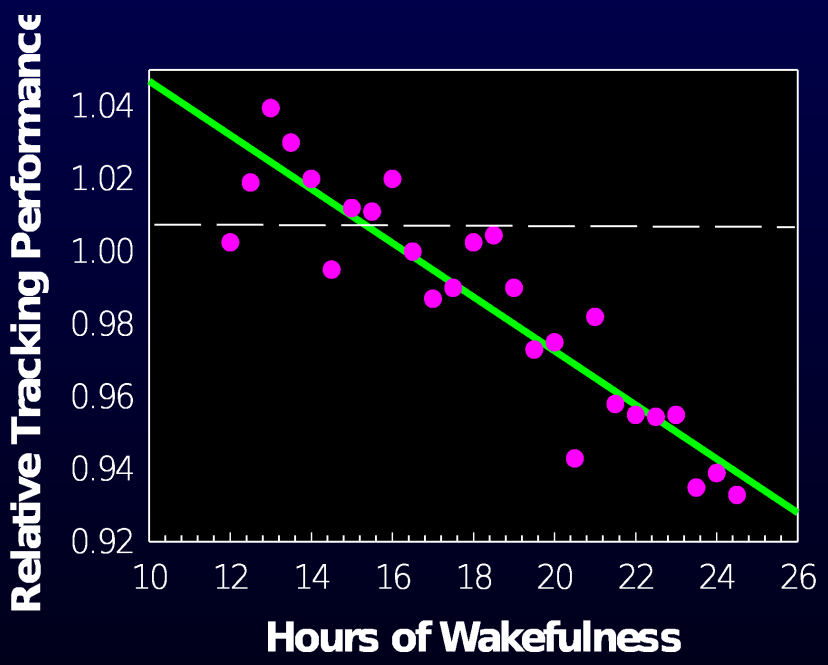
=

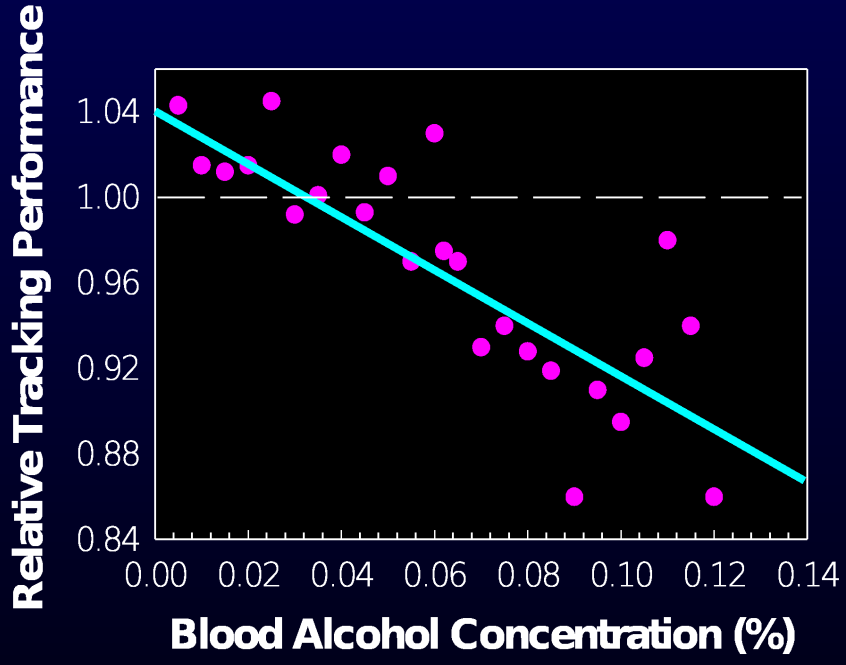
FATIGUE

Fatigue degrades performance and mental abilities

- Accuracy and timing degrade
- Lower standards of performance become acceptable
- Attentional resources are difficult to divide
- The ability to integrate information is lost
- Everything becomes more difficult to perform
- Social interactions decline
- The ability to logically reason is impaired
- Attention wanes
- Attitude and mood deteriorates
- Involuntary lapses into sleep begin to occur

Fatigue-related decrements are similar to those caused by alcohol





From: ***Dawson and Reid. (1997). Fatigue, alcohol, and performance impairment. Nature. 388:235.***

The Basic Causes of Fatigue

The basic mechanisms

- **Fatigue levels are primarily a function of two factors:**
  - **the circadian pacemaker (body clock), which makes fatigue worse at some times than at others**

    and

  - **the amount of time since the last sleep period, which is also called the homeostatic mechanism.**
- **The quality of sleep prior to the period of performance also is important.**

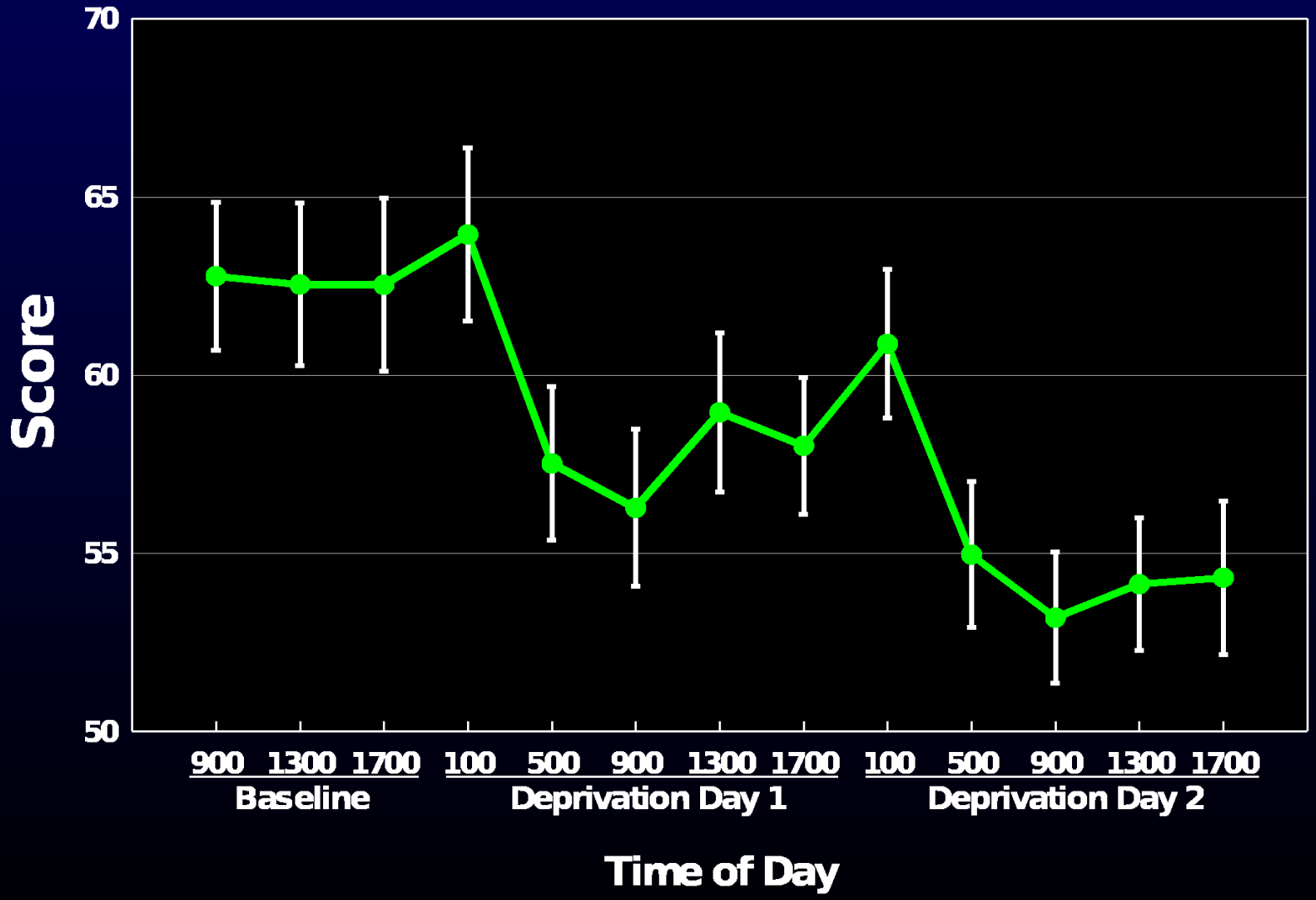
The circadian mechanism

- Time of day (according to the body's clock) is a crucial determinant of the level of alertness.
- Maximum sleepiness normally occurs during the predawn hours (between 0200 and 0500).
- But there is also a brief increase in sleepiness during the early afternoon (the post-lunch dip).
- After crossing multiple time zones, the normal period of predawn fatigue (body-clock time) may end up in the middle of the day (destination time).

The homeostatic mechanism

- Time since the last sleep episode is the most important determinant of the homeostatic part of the fatigue equation.
- Homeostatically-based sleepiness (fatigue) is low right after sleep, but increases as time passes.
- At bedtime, sleepiness is very high because the homeostatic drive for sleep is high.
- The homeostatic drive dissipates exponentially when sleep occurs.
- However, if sleep architecture is disturbed, the drive will not fully recover, even after long sleeps.
- Also, sleep restriction progressively increases the homeostatic drive for sleep.

Circadian factors and sleep loss combine to degrade performance



Circadian rhythms

- Most biological and psychological processes naturally vary on a 24-hour cycle:
  - Body temperature
  - Hormone levels
  - Alertness levels
- Light is the primary cue that makes these rhythms consistent.
- However, even people deprived of light exposure maintain a rhythm about 25 hours in length.

Disturbances of circadian rhythms

- There are hundreds of processes that run in tune based on the body clock.
- However, if something disturbs the clock, these processes fall “out of sync.”
- The most common circadian problems are:
  - **Jet lag** (the body’s clock is out of sync with external time cues because of travel).
  - **Shift lag** (the body’s clock is out of sync with external time cues because of work demands).

The problem of jet lag

- Rapid transportation from one time zone to another causes a desynchrony between the body clock and the environmental time cues.
- A time change of 3 hours or more will lead to significant jet lag.
- Jet-lag is usually short-lived and the body readjusts relatively quickly (compared to shift-work).
- It can take 1 to 2 weeks to readapt after a 5-8-hour time change.
- The rule of thumb indicates that, *at best*, 1 day of adjustment is required for each 1 hour of time change.
- It is easier to readjust after an east-west flight than after a west-east flight.

The problem of shift lag

- Shift work with night duty calls for alertness when the body clock indicates it's time for sleep, and sleep when the body is programmed to be awake.
- Night workers are sleepier at work and their productivity suffers, in part because they have shorter sleep compared to day or evening workers.
- Conflicts between schedule demands and social, lighting, and other time cues prevent full adjustment.
- Most research indicates that workers never truly adjust to night shift.
- Rotating shifts are generally seen as more problematic than fixed shifts.

Circadian and homeostatic fatigue factors in sustained operations

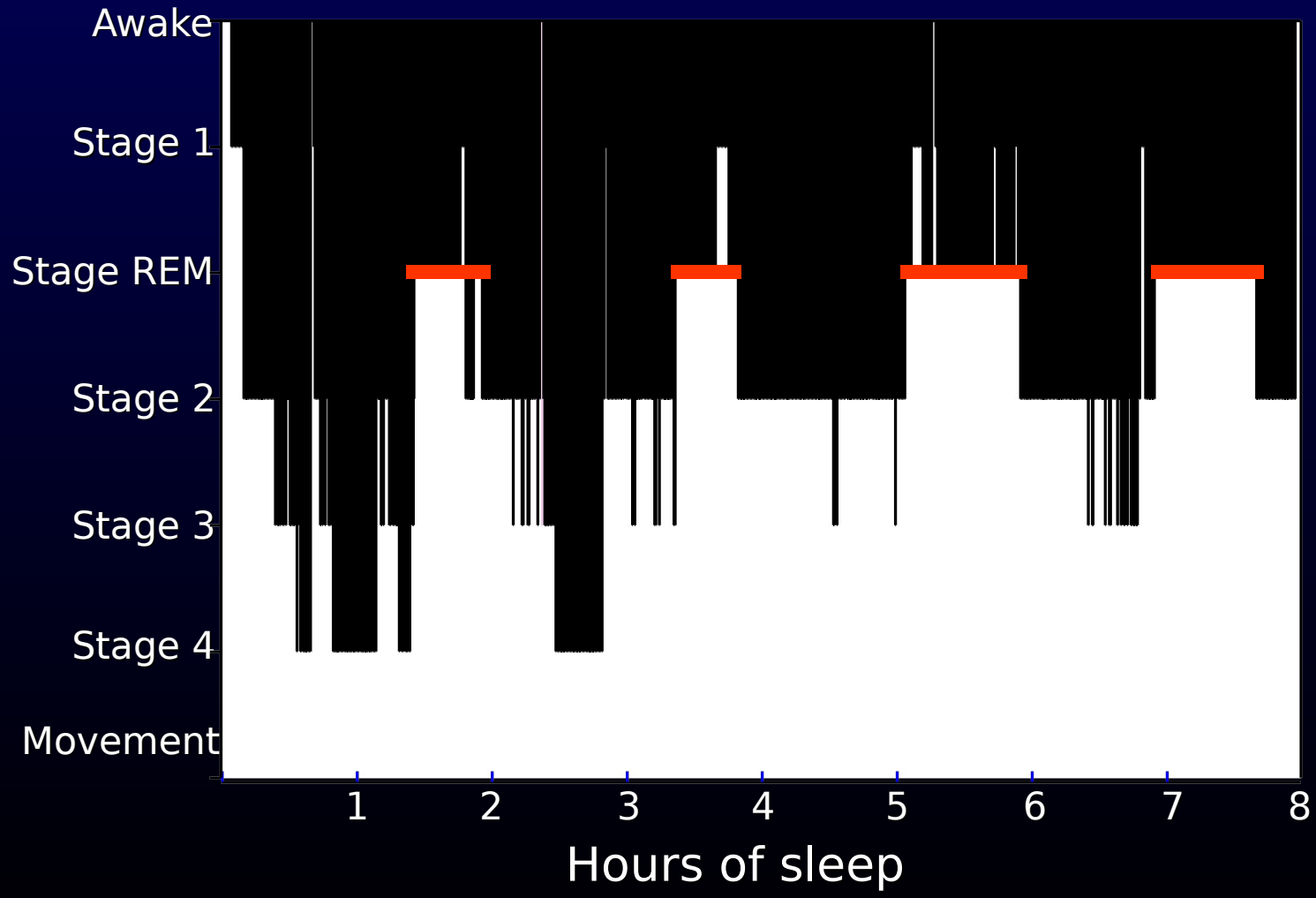
- Around-the-clock work and long-range deployments produce uncomfortable physical symptoms and fatigue from circadian factors.
- This circadian-related fatigue is exacerbated by sleep difficulties that increase the homeostatic sleep drive.

Sleep Duration (Hours)

Out-of-phase sleep is not as long or as restful as normal sleep

- The sleep cycle is disrupted by schedule changes as well as other factors.
- These disruptions produce sleep-architecture disturbances, and outright problems with insomnia.
- The lack of restful sleep creates fatigue the next day.
- Daytime sleep characteristics are different from those of nighttime sleep (the same applies to sleep after time-zone changes):
  - REM sleep onset generally occurs earlier in the sleep period.
  - Slow-wave sleep generally occurs later.

Sleep architecture can suffer from circadian disruptions



Sleep disorders will compound mission-related sleep problems

- A number of medically-recognized sleep disorders can adversely affect sleep quality:
  - Sleep apnea- numerous periods of non-breathing during the night.
  - Restless legs syndrome/Periodic limb movement disorder- frequent involuntary jerks of the limbs, usually legs, before and during sleep.
  - Narcolepsy
  - Chronic pain- arthritis, migraines, back pain, etc.
  - Gastroesophageal reflux- stomach acid backing up in the esophagus.
  - Insomnia- inability to initiate sleep and/or maintain sleep.

Other sleep problems

- In the absence of *sleep disorders, long work hours, rotating work schedules, deployment-related jet lag, and inadequate sleep opportunities*, there are other sleep-related reasons for excessive on-the-job sleepiness.
- Many of these can be effectively managed or controlled altogether. These include:
  - Transient sleep difficulties
  - Intentional sleep restriction
  - Poor sleep habits
  - Or others

Transient insomnia

- This is a short-term sleep problem that occurs in people who normally sleep well.
- The sleep problem lasts for 1-6 days.
- It is typically caused by:
  - Stress
  - Unfamiliar environments
  - Uncomfortable sleep settings
  - Circadian disruptions (when the body clock is out of phase with the work/rest schedule)

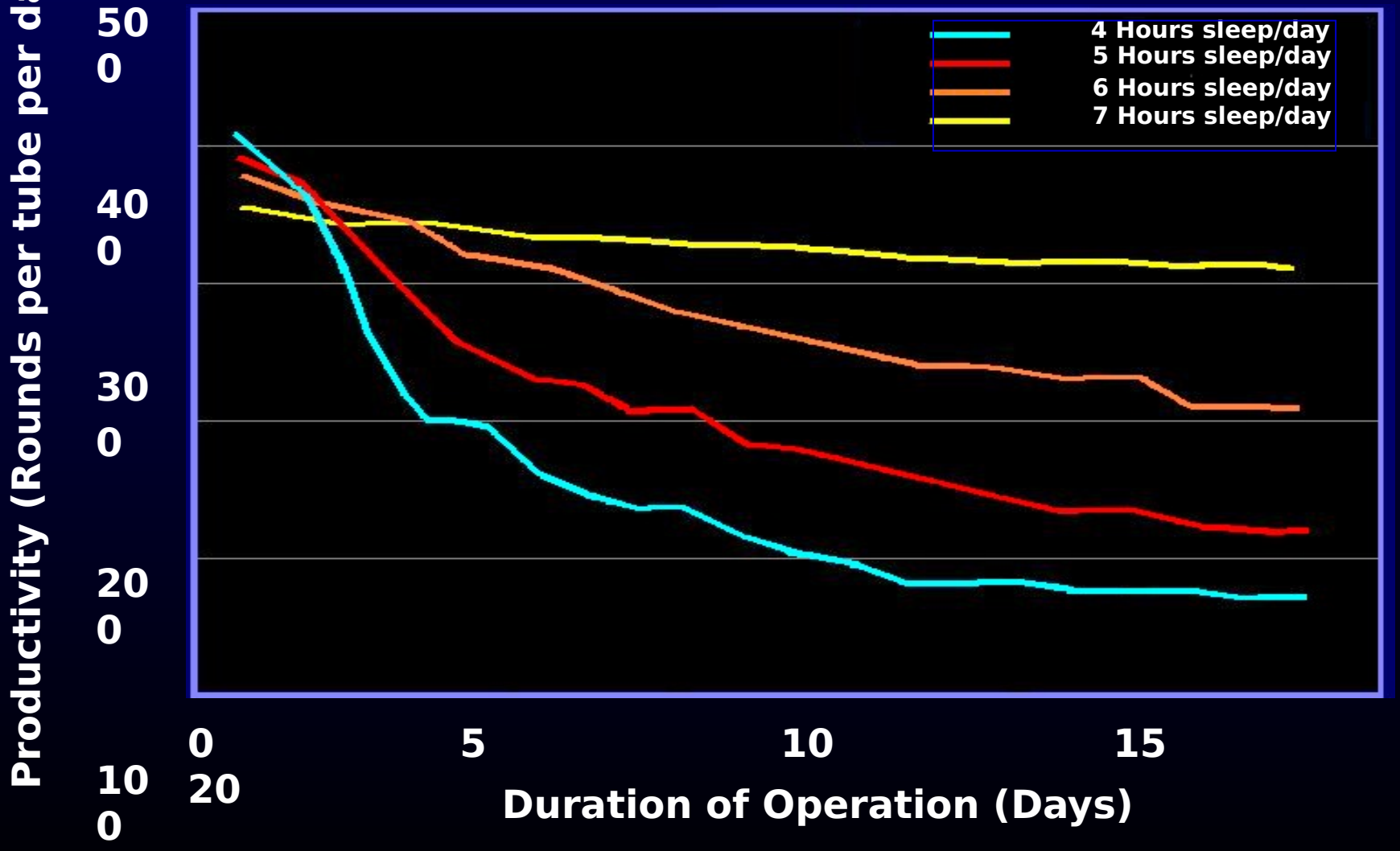
Symptoms and solutions for transient insomnia

- ***Symptoms:***
  - **Difficulty initiating and/or maintaining sleep**
  - **Sleeping more "lightly" than usual**
- ***Solutions:***
  - **Bring something familiar to the new environment (family picture, etc.).**
  - **Use a fan or air conditioner to mask out noises (or foam ear plugs).**
  - **When possible, make sure the sleep environment is cool and dark.**
  - **Maintain a program of aerobic exercise to aid sleep quality.**
  - **Use self-administered relaxation techniques.**
  - **If sleeping out of phase with circadian rhythms, use a hypnotic, and do not nap prior to bedtime.**

Intentional sleep restriction

- Many aircrew members treat sleep as an option rather than a requirement.
- Even when there is no operational requirement for sleep restriction, people sacrifice their own sleep.
- A great deal of on-the-job sleepiness results simply from going to bed too late and getting up too early.
- The average adult in the U.S. sleeps only 6 hours and 54 minutes per night during work weeks.
- This is well below the recommended amount of nightly sleep which is 8 full hours!

Effects of sleep restriction on artillery company performance

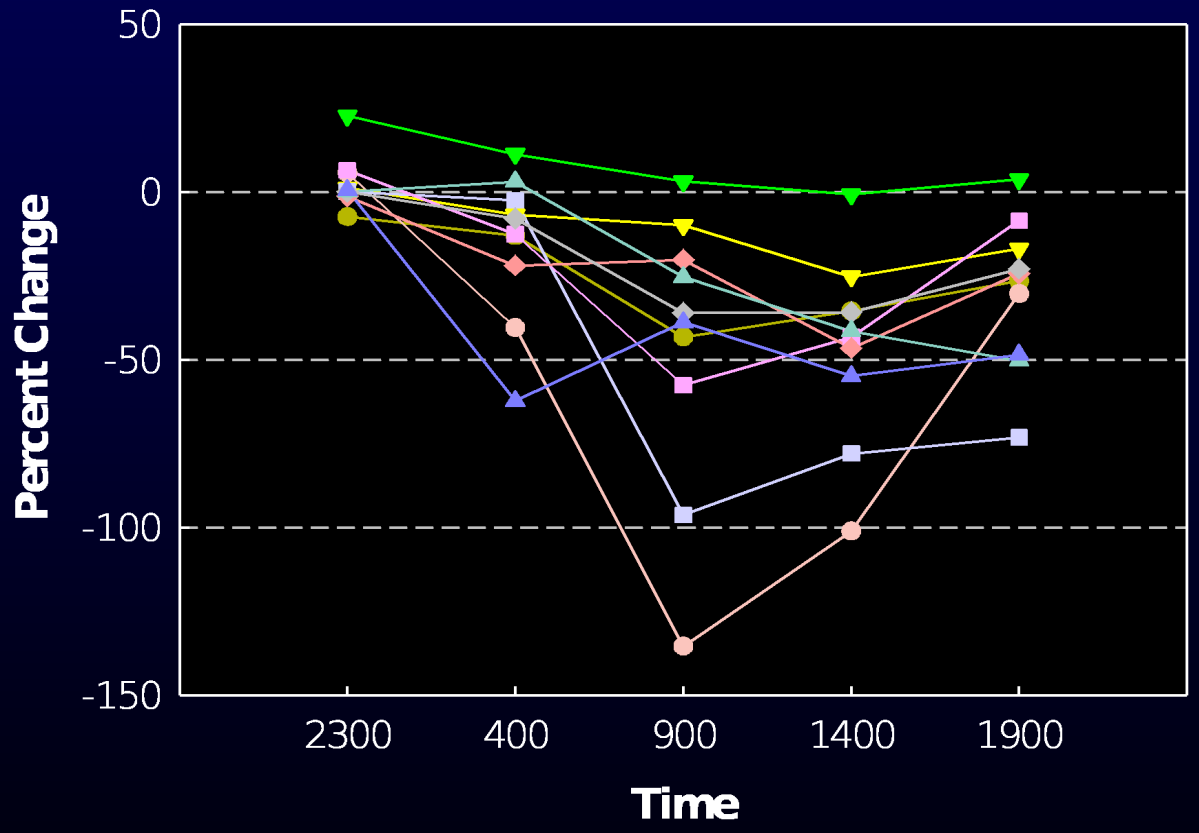


From: *Belenky, Penetar, Thorne, et al. (1994). The effects of sleep deprivation on performance during continuous combat operations. In: Food Components to Enhance Performance, National Academy Press: Washington DC, pp.*

Symptoms and solutions for intentional sleep restriction

- ***Symptoms:***
  - **Problems with going to sleep while watching TV, attending meetings, conversing with others, working, or driving *or flying.***
- ***Solutions:***
  - **Evaluate the amount of time spent asleep each night.**
  - **Gradually lengthen the sleep period until daytime sleepiness subsides.**
  - **Ignore what other people say about how much sleep is necessary (*individual sleep needs and the extent of fatigue vulnerability differ quite a bit).***

Individual differences in fatigue vulnerability



People who are already fatigue vulnerable will really suffer from restricted sleep!

Caldwell, Mu, Smith, et al. (2004). Are individual differences in fatigue vulnerability related to baseline differences in cortical activation? *Behavioral Neuroscience*, in press.

Poor sleep hygiene

- For many people, falling asleep and sleeping well come naturally.
- However, many personnel defeat these good natural tendencies with lifestyle and dietary habits that cause insomnia.
- Generally, poor sleep habits involve behaviors, diets, substances, or environmental factors (light, noise, etc.) that are not conducive to restful sleep.
- Insomnia from bad sleep habits can be eliminated by consciously working on better sleep hygiene.

Specific recommendations for good sleep habits

- Stick to a consistent wake-up and bedtime every day of the week.
- Use the bedroom only for sleep and sex.
- Resolve daily dilemmas outside of the sleep area.
- Engage in a consistent “getting ready for bed” routine as often as possible.
- Establish an exercise routine and stick to it.
- Create a quiet and comfortable sleep environment.
- Don’t consume caffeine within 4 hours of bedtime.
- Don’t use alcohol as a sleep aid.
- Don’t take naps during the day.
- Don’t smoke cigarettes immediately before bed.

The bottom line

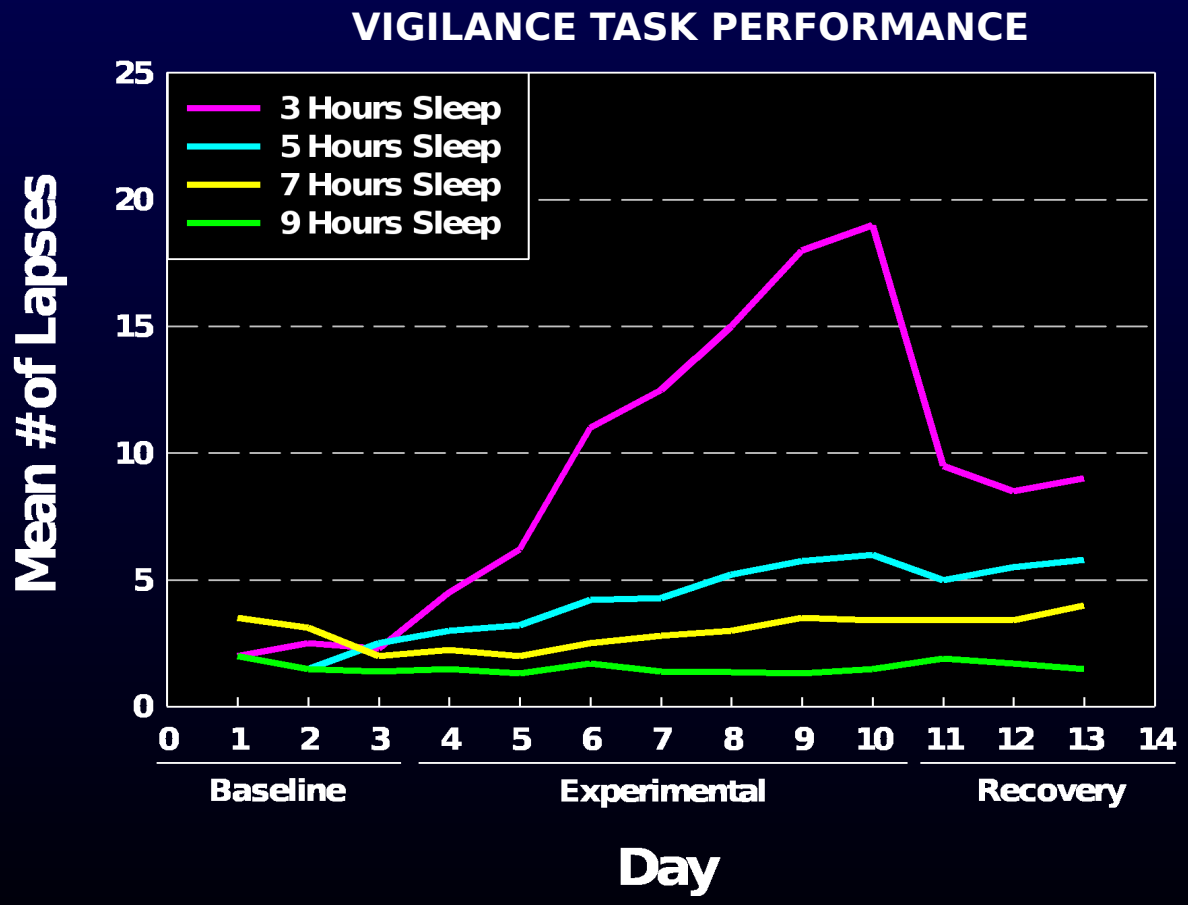
- The best way to avoid fatigue on the job is to get enough sleep before reporting for duty.
- Both leaders and personnel should make sleep a priority when schedules are made.
- Few other strategies will do more to avoid fatigue and improve alertness, performance, and well being.
- There is no substitute for adequate sleep on a day-to-day basis!

Fatigue Countermeasures

In the operational context, adequate sleep is crucial for mission success

- **Sleep restriction severely degrades performance.**
- **When sleep is less than *5 hours per night*, fatigue becomes a problem almost immediately.**
- **When sleep is cut to less than *4 hours per night*, uncontrolled sleep attacks occur.**
- ***Seven hours per night* is the minimum requirement.**
  - ***However, the average requirement is 8 h, and some people will need more.***
  - **Personnel will know they've found the right amount when it's easy to stay alert even during boring and/or sedentary tasks.**
- **Personnel cannot train themselves to get by on less sleep!**

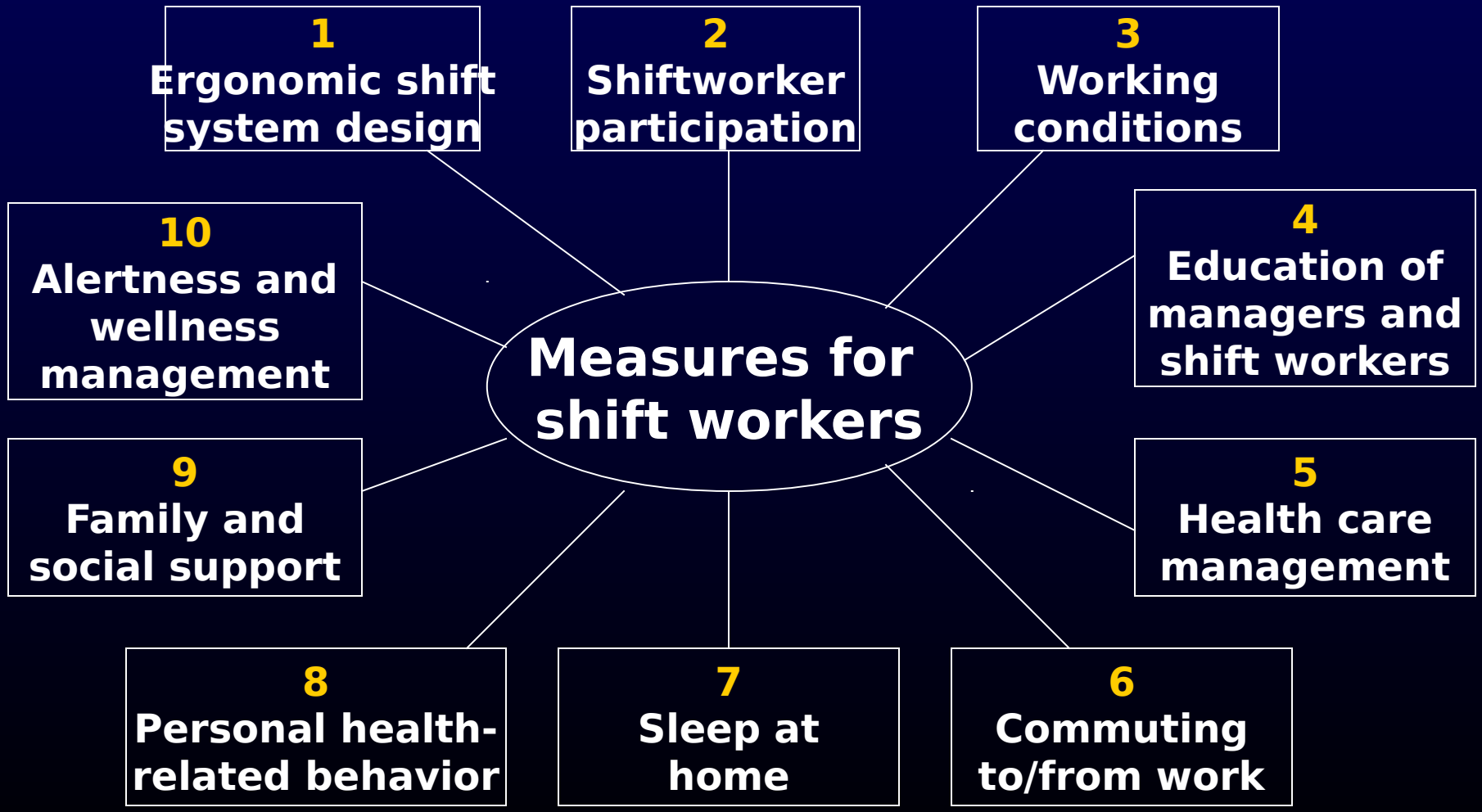
Chronic sleep restriction has its price



Balkin et al., 2000

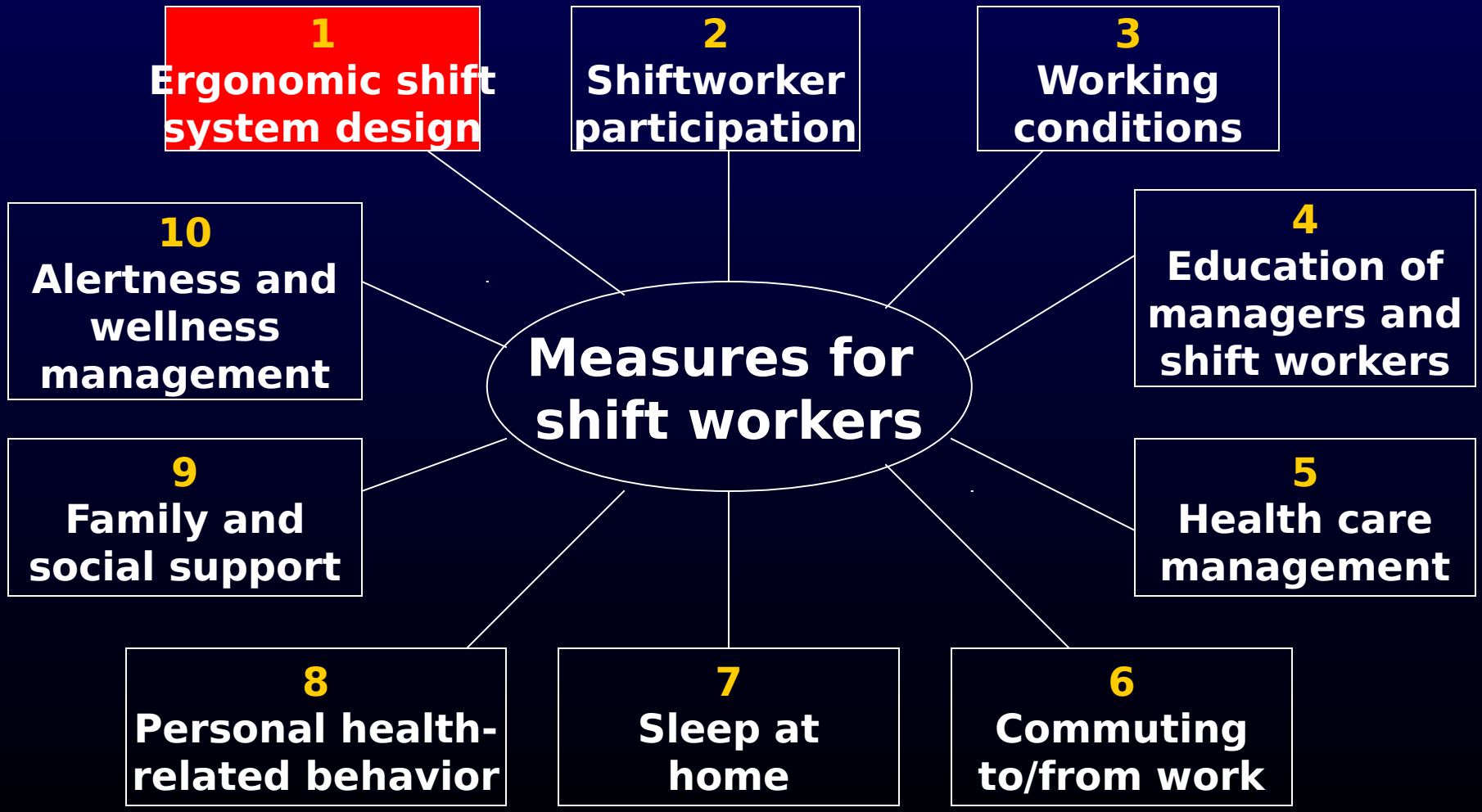
Fatigue Countermeasures and Other Considerations for Shift Workers

Shift workers need special attention



From: ***Knauth and Hornberger. (2003). Preventive and compensatory measures for shiftworkers. Occupational Medicine, 53:109-116.***

Shift workers need special attention



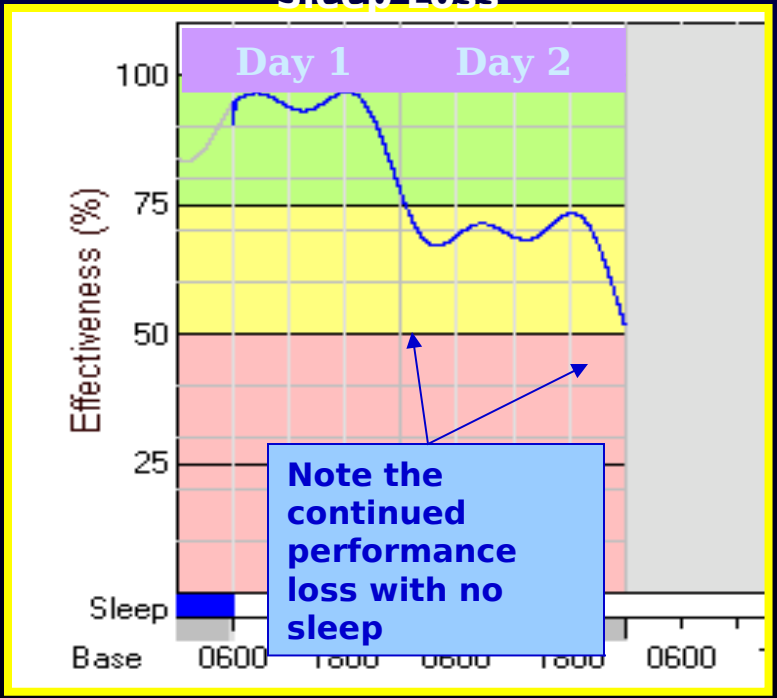
From: ***Knauth and Hornberger. (2003). Preventive and compensatory measures for shiftworkers. Occupational Medicine, 53:109-116.***

Ergonomic recommendations

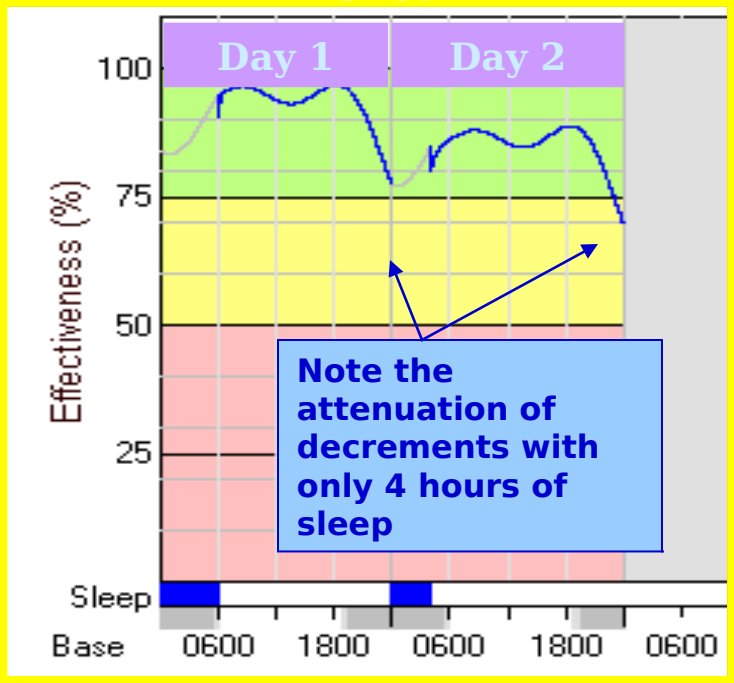
- **Avoid placing personnel on permanent night shift.**
- **Limit the number of consecutive night shifts.**
- **Schedule as few early morning shifts as possible, max of 3.**
- **Create a forward-rotation schedule (Day>Evening>Night).**
- **Give at least 2 days off for recovery after the last night shift.**
- **Avoid single-day shift rotations (i.e., D-E-N-D).**
- **Limit number of continuous work days to 5 or 7.**
- **Keep in mind that from a strictly circadian point of view:**
  - Worst schedule = weekly or longer backward rotation.
  - Best schedule = fast forward rotation (2 days per shift).

Computerized scheduling tools can estimate risky work times and help schedule optimal work/rest periods

Performance Decrement with Sleep Loss



Improvement with a Short Sleep Period



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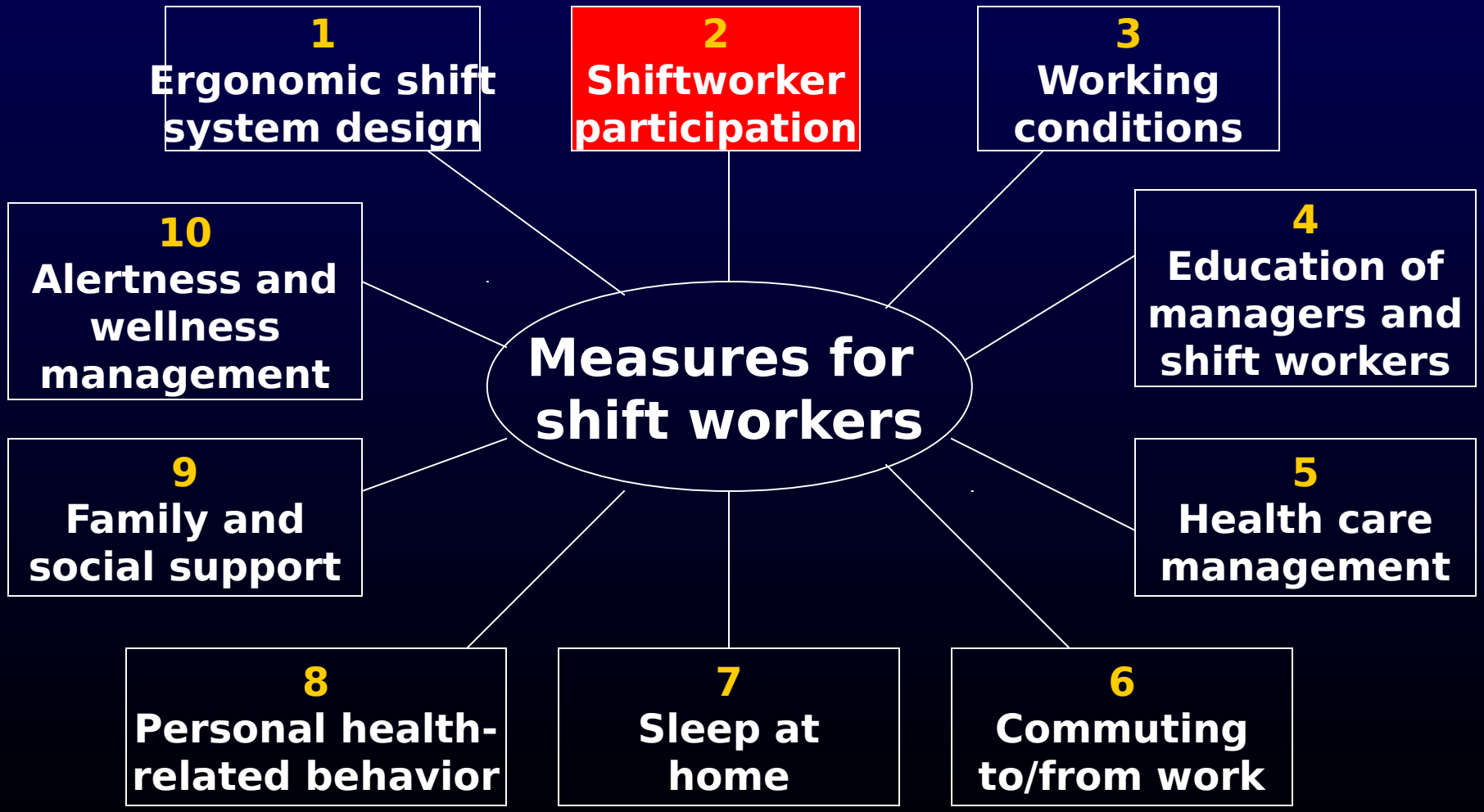
Shift workers need special attention

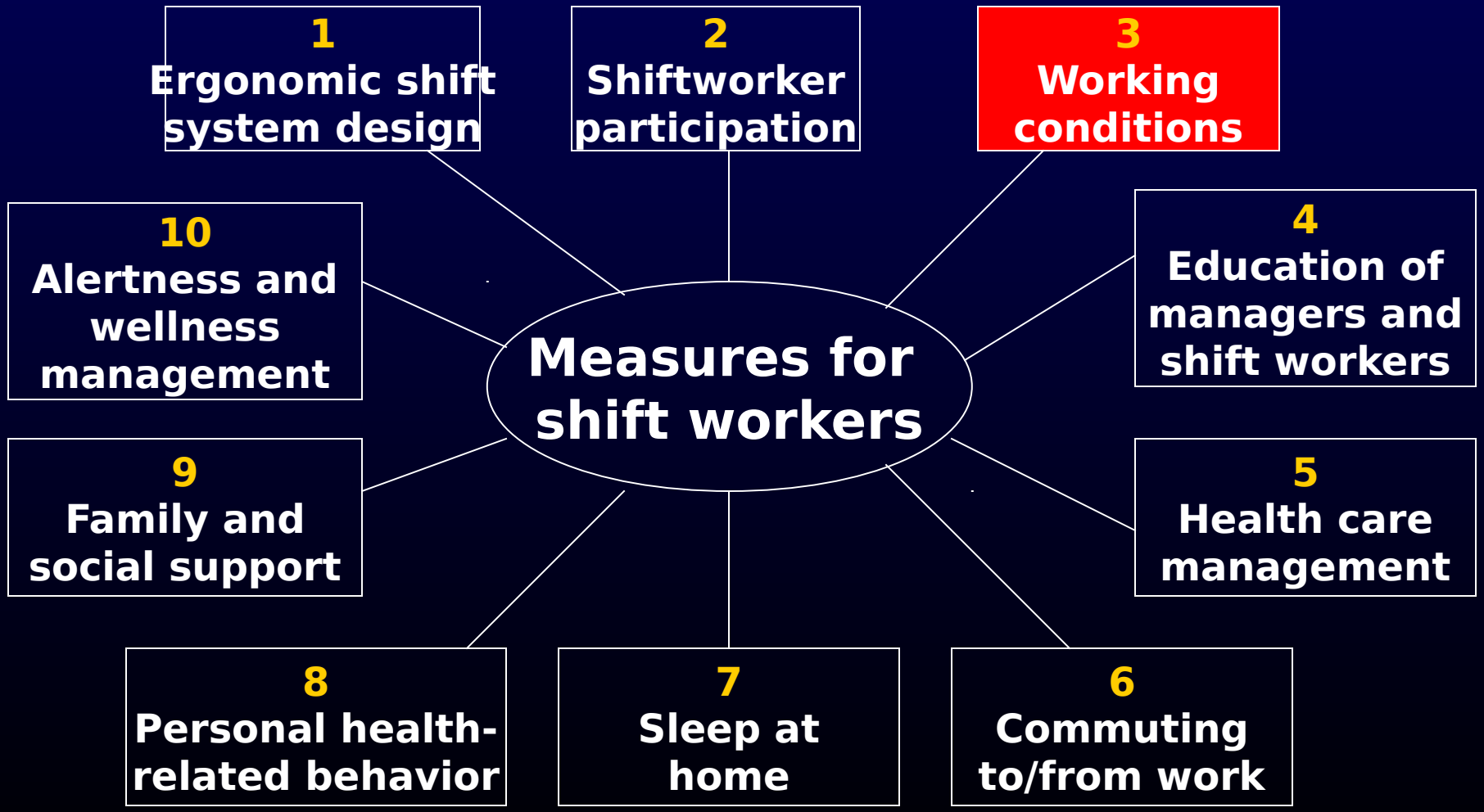


From: ***Knauth and Hornberger. (2003). Preventive and compensatory measures for shiftworkers. Occupational Medicine, 53:109-116.***

Shift worker participation is a plus

- Allowing input into the shift system gives workers a higher acceptance into the system.
- Encourage information exchange and communication.
- Provide adequate project management.
- Provide an evaluation of the effects of the system on both the company and the workers.

Shift workers need special attention



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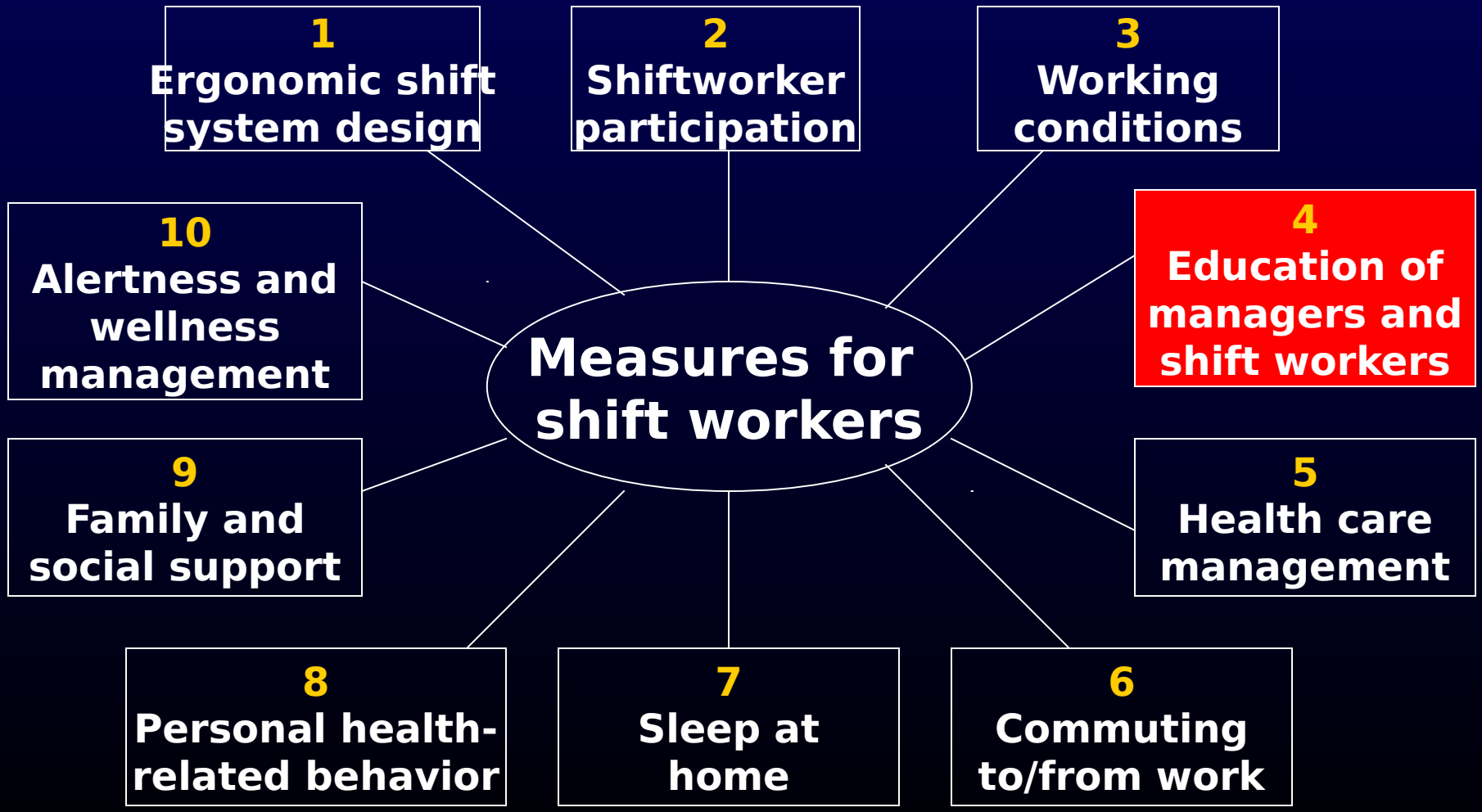
Optimum working conditions will lessen the impact of shift work

- Provide adequate staff.
- Equalize the work load.
- Rotate job duties if possible.
- Minimize environmental exposures.
- Provide rest breaks.
- Allow commuting and social/family time between shifts.

Shift workers need special attention

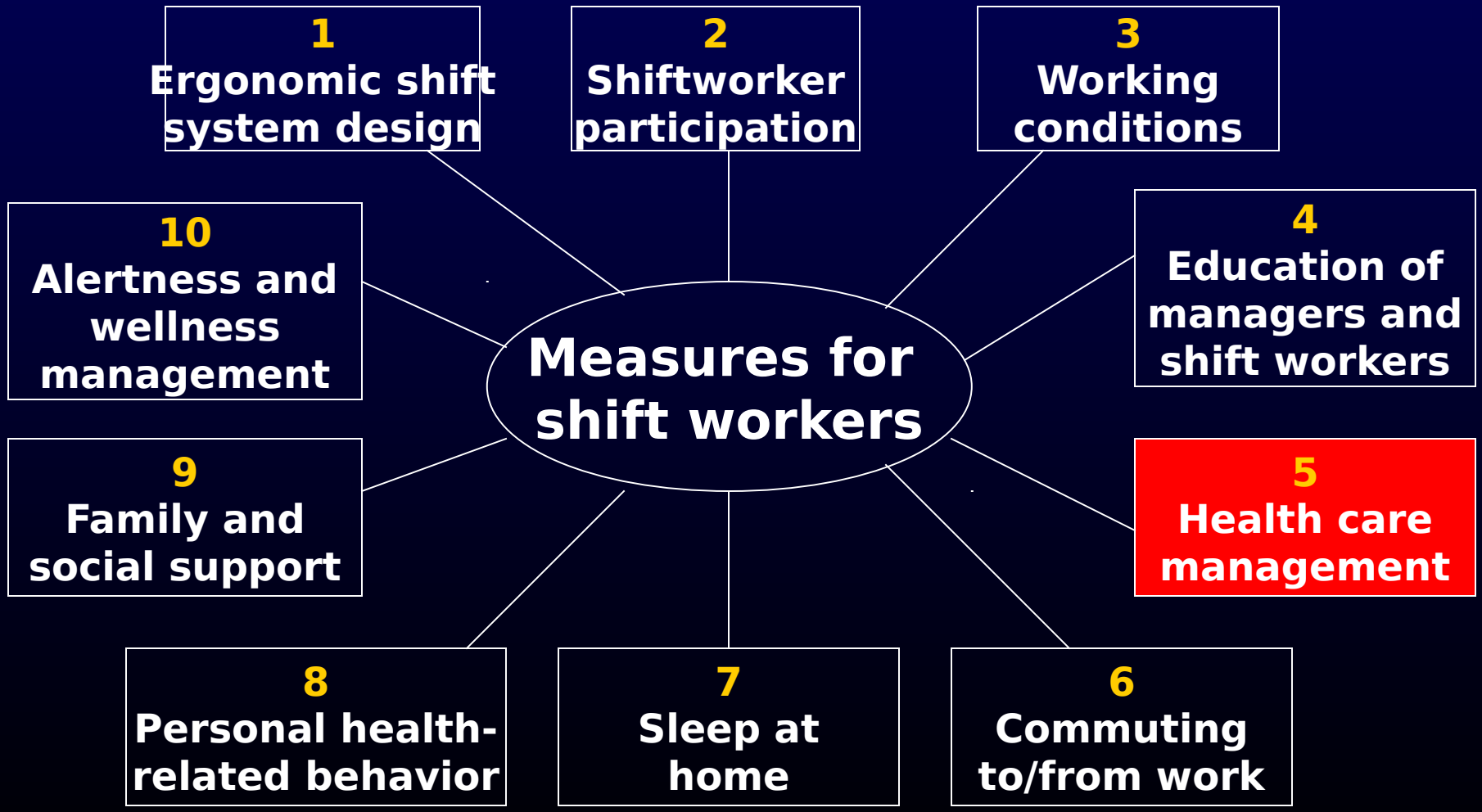


From: ***Knauth and Hornberger. (2003). Preventive and compensatory measures for shiftworkers. Occupational Medicine, 53:109-116.***

workers about the complexities of working various hours

- Expose new managers to a shift work lifestyle for several shift cycles.
- Provide workshops/seminars to managers.
- Start the education with senior management.
- Shift worker education can help alleviate some of the conflicts between employees and management.

Shift workers need special attention

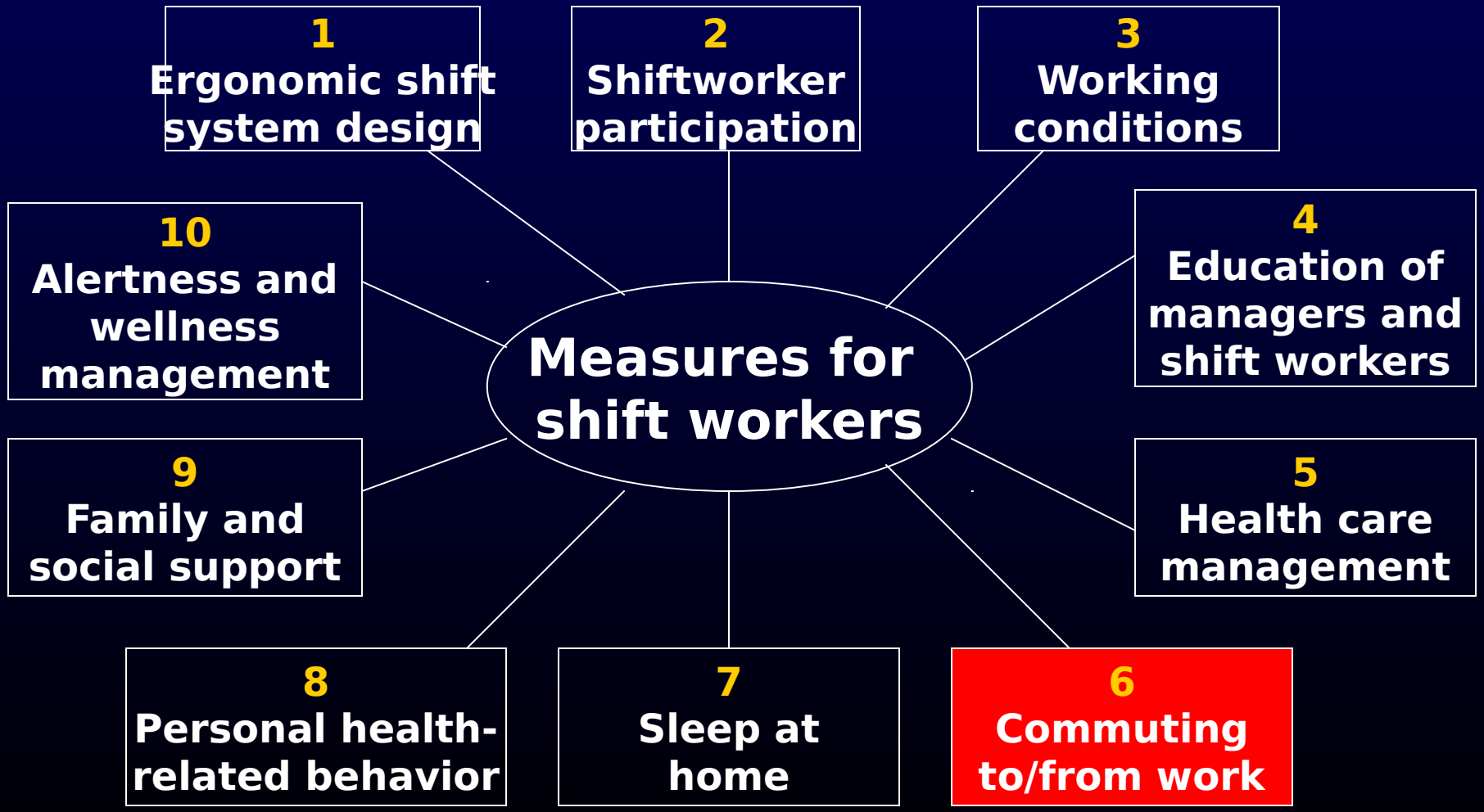


From: ***Knauth and Hornberger. (2003). Preventive and compensatory measures for shiftworkers. Occupational Medicine, 53:109-116.***

Shift workers, especially night workers, need special health-care consideration

- Provide medical surveillance of shift workers.
- Make company medical staff available during the night shift.
- Educate the medical staff on knowledge of sleep disorders and shift maladaptation syndrome.
- Allow health-care workers to consult with management about the design of shift systems to minimize impact on workers' health.

Shift workers need special attention



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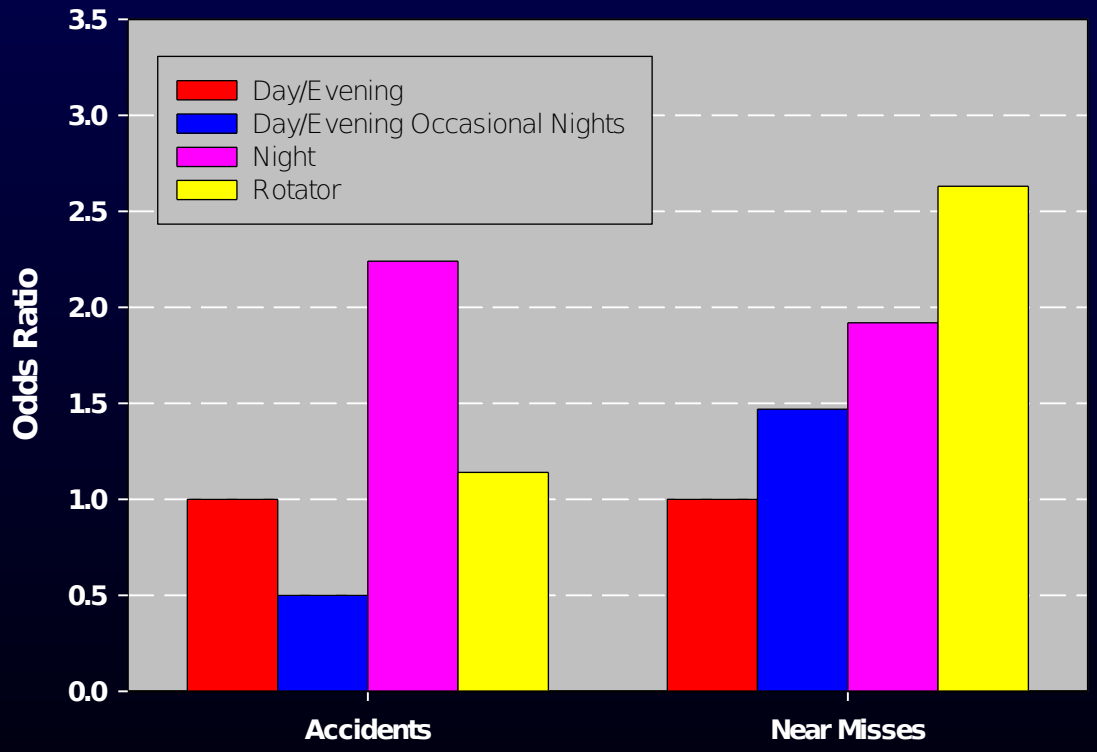
Sometimes the drive home is the most dangerous part

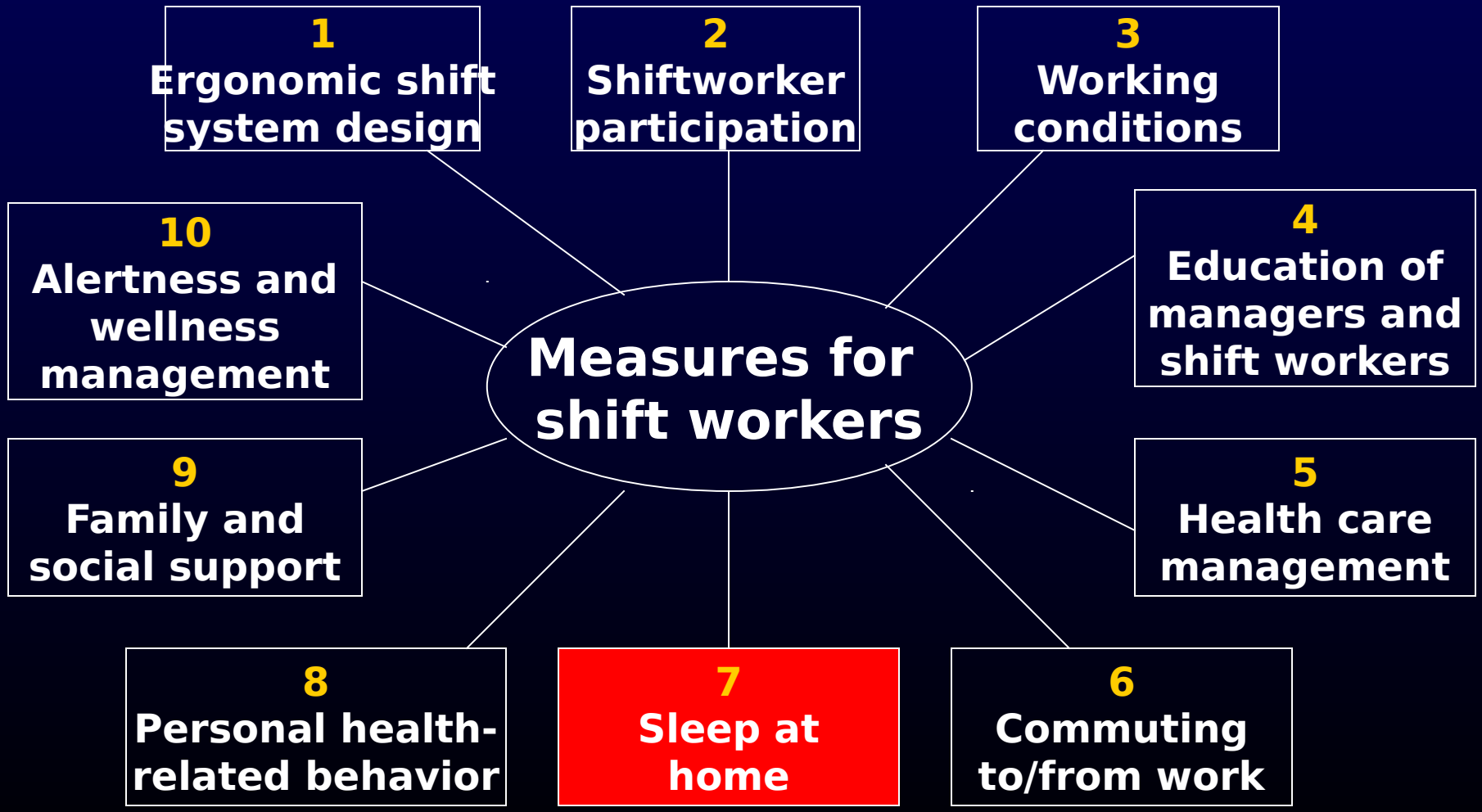


From: *Gold et al. (1992). Rotating shift work, sleep, and accidents related to sleepiness in hospital nurses. American Journal of Public Health, 82(7):1011-1014.*

Consider the following for improving the commute home

- **The employer can consider:**
  - A company car pool
  - A place to nap before driving home
- **The shift worker can consider:**
  - A cool car interior
  - Vary the route
  - Use public transportation

Shift workers need special attention

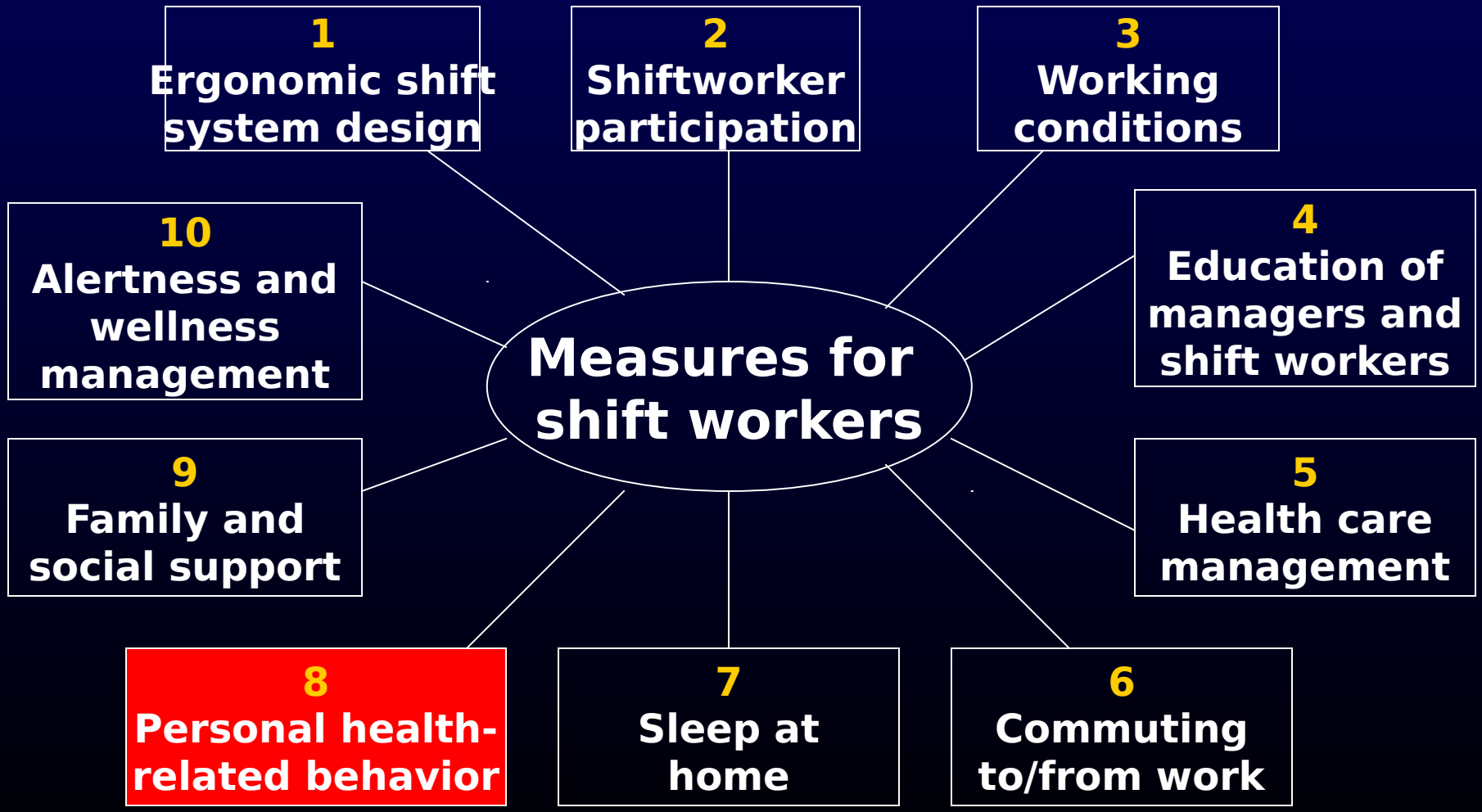


From: ***Knauth and Hornberger. (2003). Preventive and compensatory measures for shiftworkers. Occupational Medicine, 53:109-116.***

Educate the shift worker on good sleep hygiene

- Night workers encounter sleep problems unique to daytime sleep episodes.
- Educating workers about these problems and the best countermeasures.
- Emphasize the need for a good sleeping environment.
- Ensure that family and friends understand the shift worker's need for sleep.
- Advise shift workers to compensate for lost sleep with naps *(to be discussed shortly).*

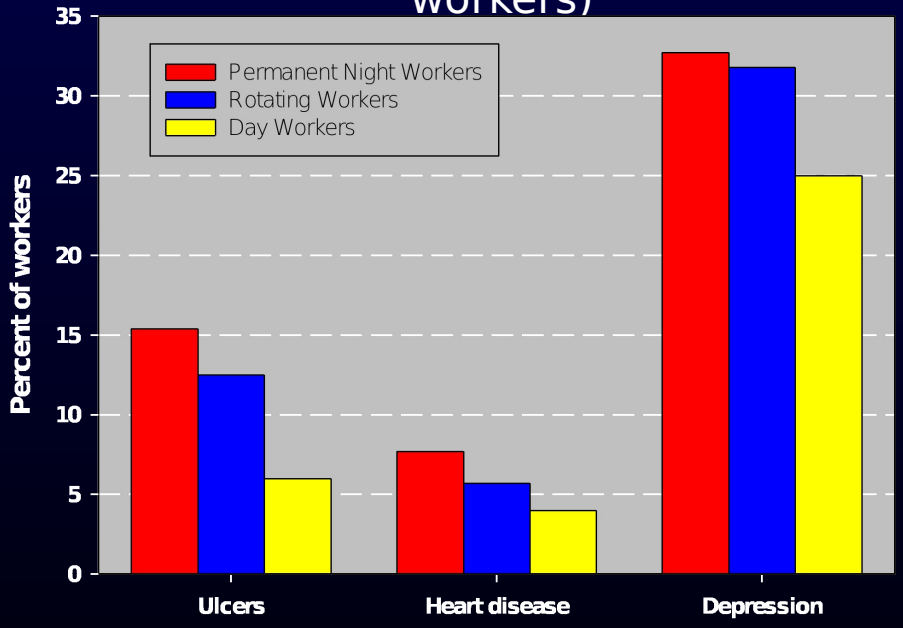
Shift workers need special attention



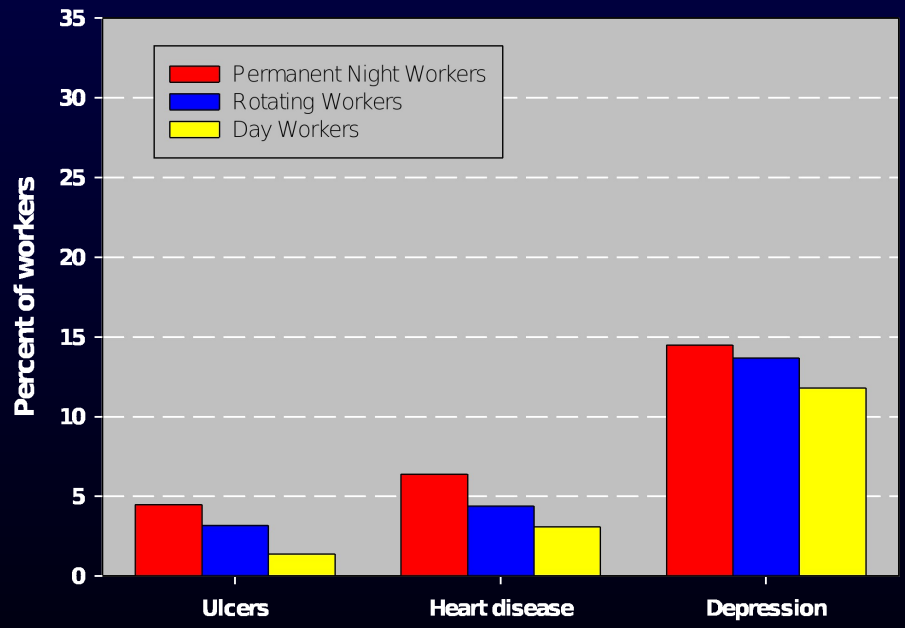
From: ***Knauth and Hornberger. (2003). Preventive and compensatory measures for shiftworkers. Occupational Medicine, 53:109-116.***

Shift workers are known to be at a general health disadvantage

Workers diagnosed with Shiftwork Sleep Disorder (Insomnia for Day workers)



Workers not diagnosed with Shiftwork Sleep Disorder

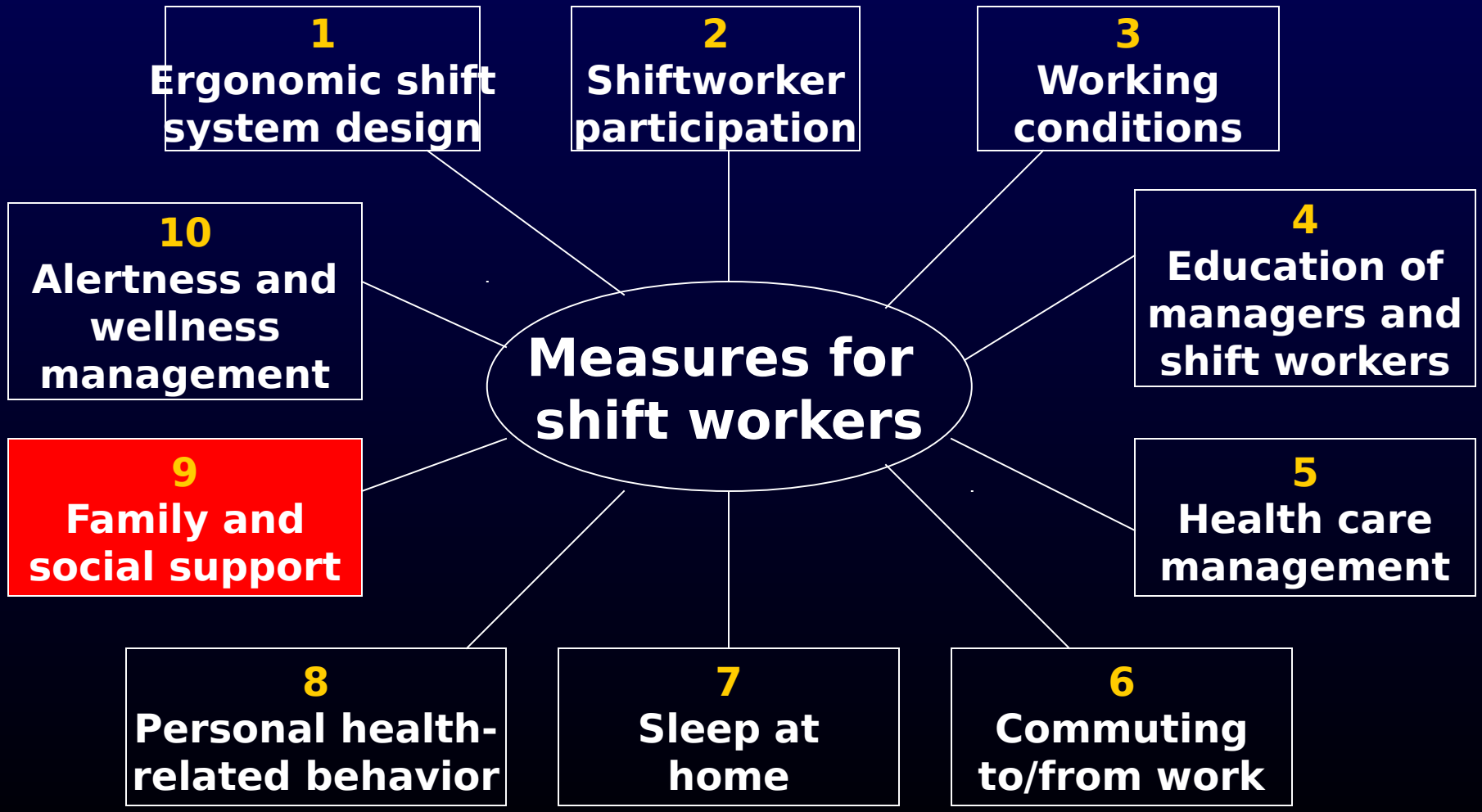


From: *Drake, Roehrs, Richardson, Walsh, Roth. (2004) Shift Work Sleep Disorder: Prevalence and consequences beyond that of symptomatic day workers. Sleep, 27(8):1453-1462.*

Ensure shift workers are familiar with “healthy behaviors”

- **Adapt good eating habits**
  - For night workers: Eat a light main meal about 0000-0100, and a snack during the sleepy hours between 0300-0400.
  - Avoid large, fatty meals; eat foods high in protein.
  - Develop a regular eating routine of three meals a day, regardless of the shift one is working.
- **Use caffeine appropriately**
  - Include caffeine consumption within the first 2 hours of the night shift, but avoid it during the second half.
- **Improve physical fitness**
  - May improve sleep length and quality.
  - May help with night shift alertness.
  - Decreases general fatigue.

Shift workers need special attention

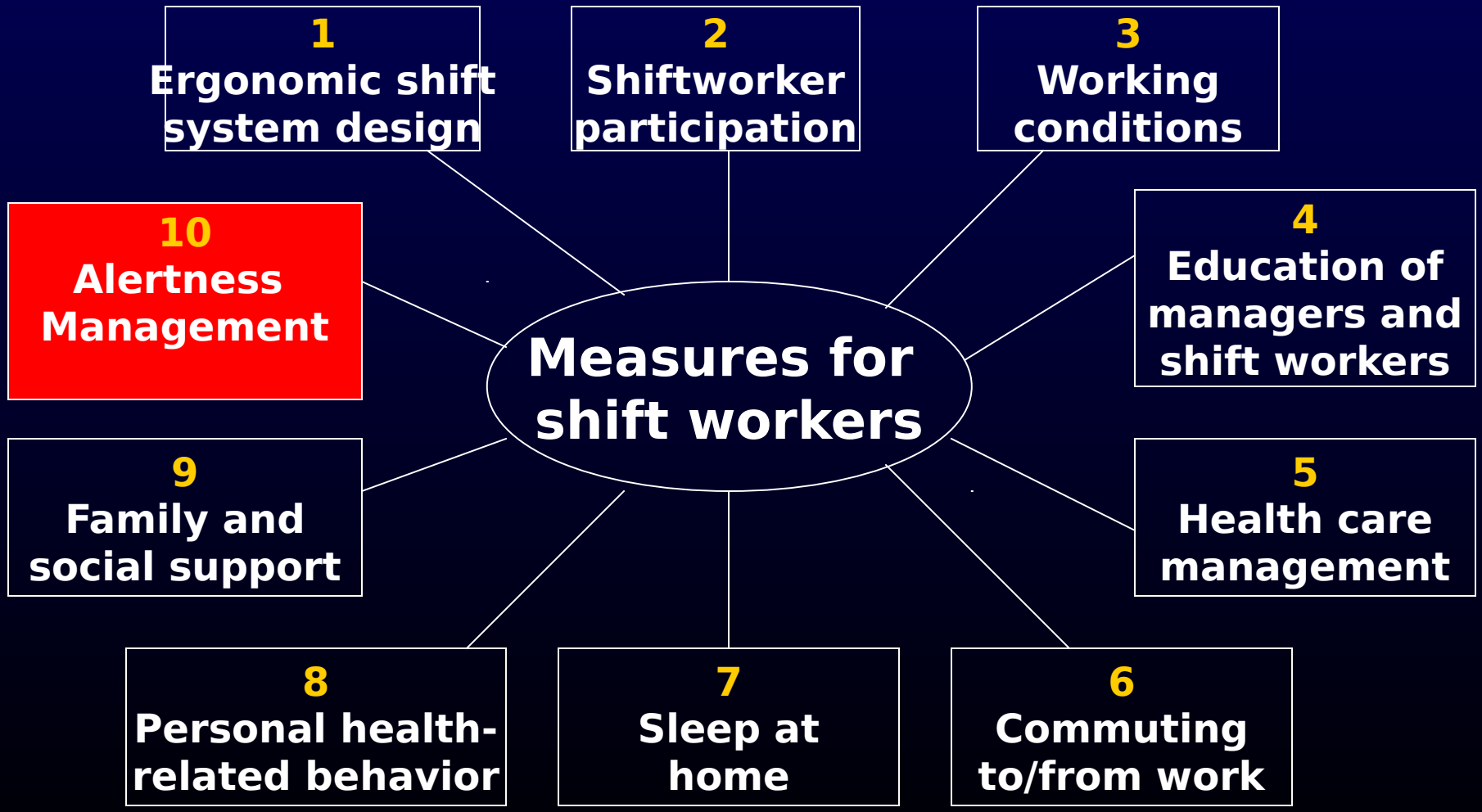


From: ***Knauth and Hornberger. (2003). Preventive and compensatory measures for shiftworkers. Occupational Medicine, 53:109-116.***

Bolster well-being through strong family/social ties

- Educate significant others about shift work.
- Emphasize the importance of balancing family and sleep time.
- Ensure the worker stays in touch with family plans.
- Discuss the importance of reserving time to socialize with family and friends.
- Suggest developing supportive social networks (i.e., spending time with other shift workers' families).

Shift workers need special attention



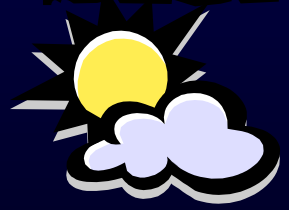
From: ***Knauth and Hornberger. (2003). Preventive and compensatory measures for shiftworkers. Occupational Medicine, 53:109-116.***

Optimize on-the-job alertness with several strategies

- **Bright light can reset the body clock when changing to a new schedule.**
  - **A 2- to 3-hour light pulse is needed.**
  - **Light in the evening will help delay sleep in night workers.**
  - **At best light can shift the clock 3 hours per day.**
- **Better daytime sleep will improve nighttime performance.**
  - **Temporary hypnotic therapy is effective to decrease homeostatic sleep pressure.**
- **Judicious use of caffeine will temporarily relieve nighttime fatigue.**
  - **Caffeine and other stimulants will be discussed shortly.**

Intensity levels of various light sources

Sunny Day -- 100,000 lux



Cloudy day -- 10,000 lux

Bright artificial light -- 2,000 lux

Ordinary indoor light -- 200 lux

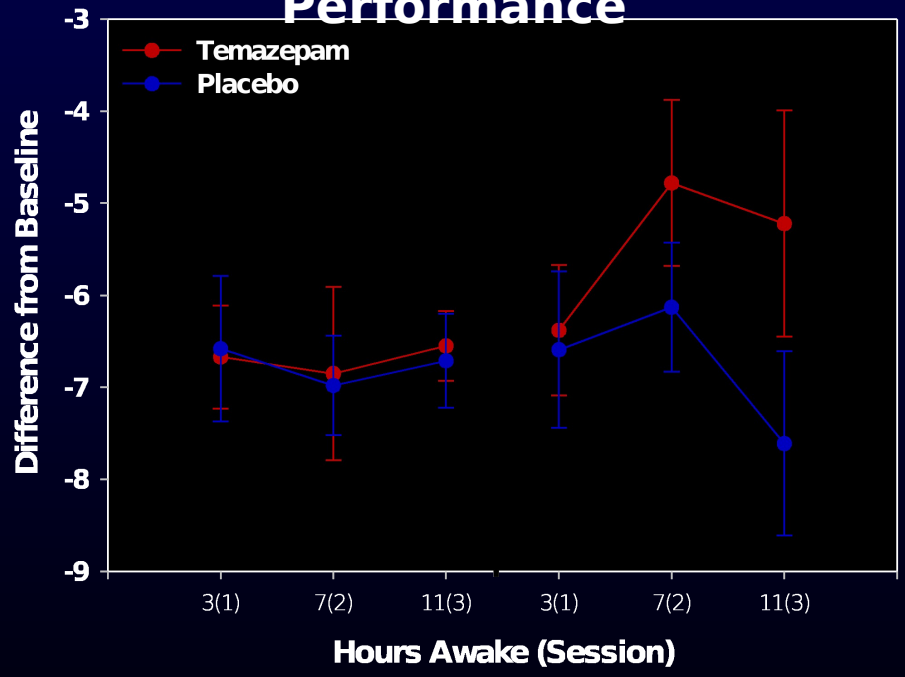
Consider hypnotics when circadian factors make sleep difficult

- Both temazepam (Restoril®) and zolpidem (Ambien®) can effectively promote “out of phase” sleep.
- Studies of temazepam have shown that it can significantly improve daytime sleep and nighttime performance (in shiftwork operations).
- The standard dose of Restoril® is 30 mg before bedtime.
- Zolpidem (10 mg) also can improve short periods of “out of phase” sleep. It is better for naps.
- Both of these medications can minimize the impact of shift lag and jet lag.

sleep and subsequent nighttime performance

Daytime Sleep Parameters

Nighttime Simulator Performance



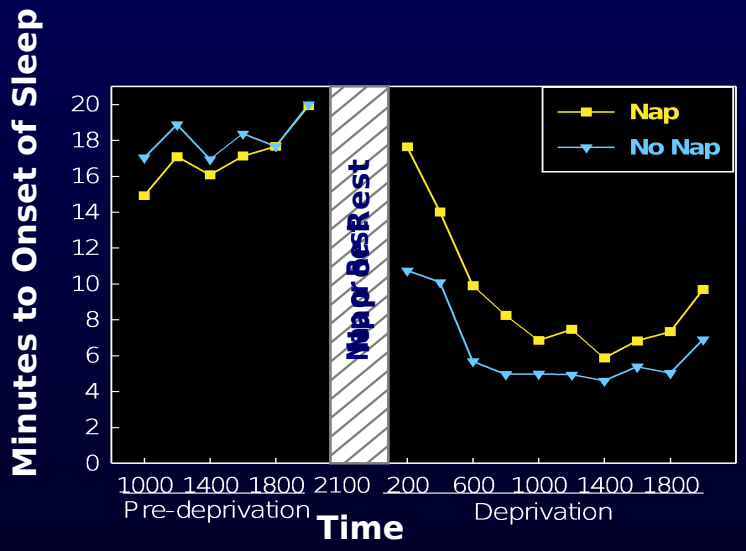
From: ***Caldwell, Prazinko, Rowe, Norman, Hall, and Caldwell. (2003). Improving daytime sleep with temazepam as a countermeasure for shift lag. Aviation, Space, and Environmental Medicine, 74(2):153-163.***

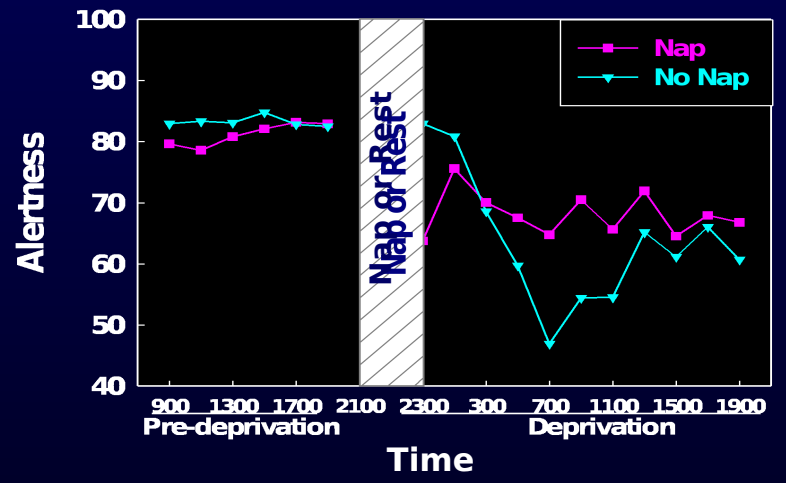
Fatigue Countermeasures for Everyone

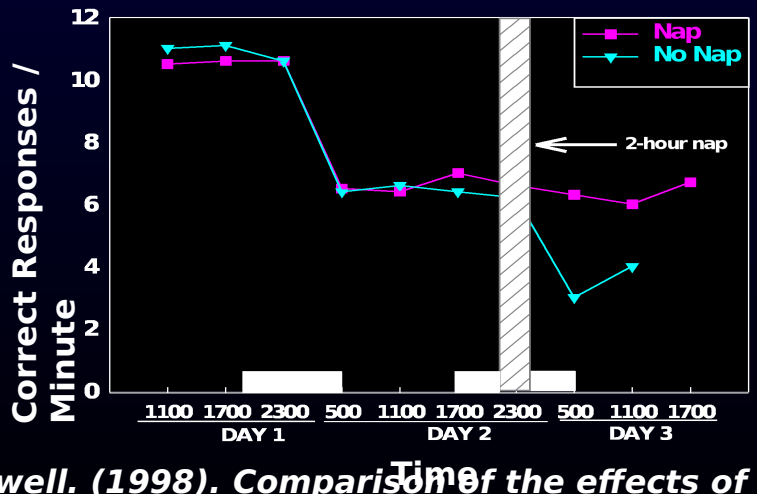
Strategic naps are very effective

- Naps can be used prophylactically to maintain performance during a subsequent period of prolonged wakefulness.
- Naps also can be used to arrest the performance decline that occurs from sleep deprivation.
- The basic principle behind napping is that it reduces the length of time between the last sleep period and the subsequent performance period.
- Naps have been proven to maintain or improve mood, performance, and alertness in a variety of situations.

Naps can bridge the gap between consolidated sleep periods







From: ***Caldwell and Caldwell. (1998). Comparison of the effects of zolpidem-induced prophylactic naps to placebo naps and forced rest periods in prolonged work schedules. Sleep, 1998, 21(1):79-90. ; Angus et al., 1992***

Points to consider when using naps in operational settings

- **A quiet, dark, cool environment is the most conducive to sleep.**
  - ***Mask out noise with foam ear plugs.***
  - ***Minimize light exposure with a sleep mask.***
- **It is easier to sleep at some times of the day than others.**
  - ***Between 0100-0500 is the best time.***
  - ***But afternoon naps between 1400-1600 are a good alternative.***
- **It is better to place naps early in the period of continuous wakefulness.**
  - ***It is easier to attenuate declines in alertness than it is to restore alertness that has already declined.***
- **The longer the nap the better its effects.**
  - ***There is a dose-response relationship between sleep and alertness.***
- **However, be sure to allow time for sleep inertia to dissipate.**

Sleep medications can promote naps in non-sleep-conducive settings

- If a napping opportunity becomes available…

but

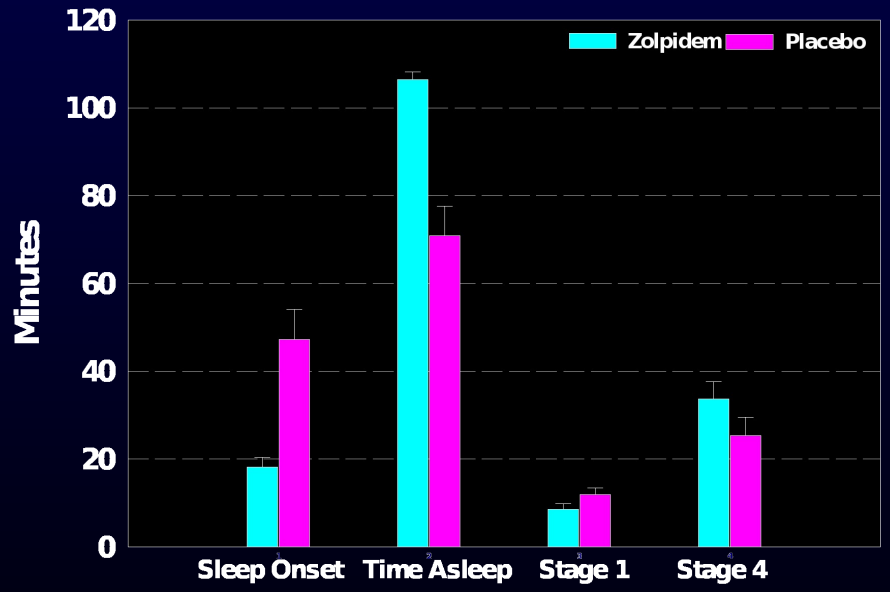
- The nap occurs at a non-sleep-conducive time,

then

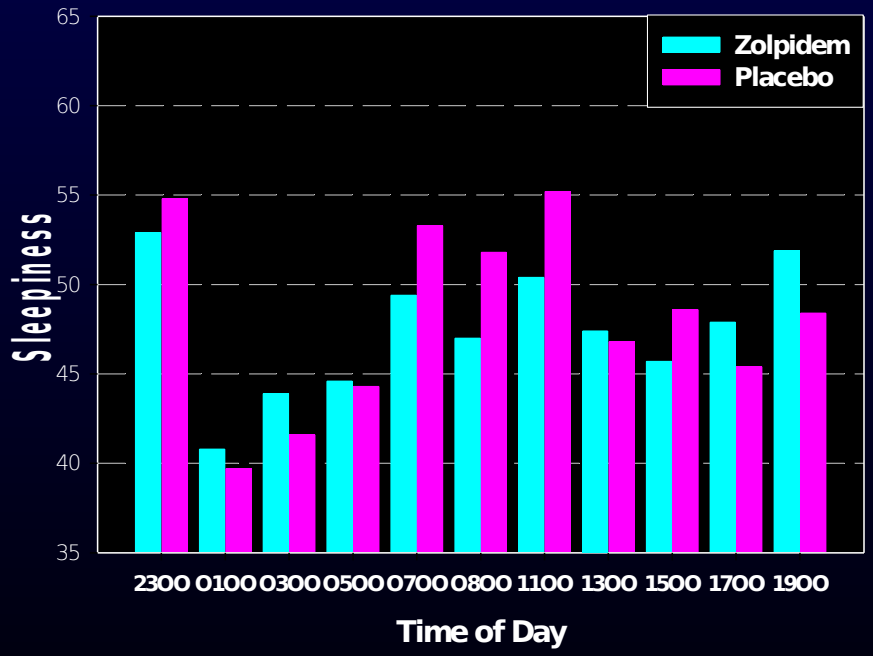
- Consider zolpidem (Ambien®) or zaleplon (Sonata®).
  - Zolpidem has a half life of only 2.5 hours.
  - Zaleplon has a half life of only 1 hour.
- Both are good choices for initiating and maintaining short periods of sleep (naps).

Zolpidem improves sleep at inopportune times and then improves alertness later

Nap Sleep Parameters



Sleepiness Ratings



From: *Caldwell and Caldwell. (1998). Comparison of the effects of zolpidem-induced prophylactic naps to placebo naps and forced rest periods in prolonged work schedules. Sleep, 1998, 21(1):79-90.*

Military guidance on hypnotics

- **Army guidance—Rest Agents, No Waiver Required:**

Medication	Dose	Half-life	Grounding
Temazepam (Restoril®)	15 or 30 mg	8.0-12.0 h	24 hours
Triazolam (Halcion®)	0.125 or 0.25 mg	2.0- 4.0 h	9 hours
Zolpidem (Ambien®)	5 or 10 mg	2.0- 2.5 h	8 hours
Zaleplon (Sonata®)	5 or 10 mg	1.0 h	8 hours

- **Air Force guidance—No-Go Pills, No Waiver Required:**

Medication	Dose	Half-life	Grounding
Temazepam (Restoril®)	15 or 30 mg	8.0-12.0 h	12 hours
Triazolam (Halcion®)	Not authorized	na	na
Zolpidem (Ambien®)	10 mg	2.0- 2.5 h	6 hours
Zaleplon (Sonata®)	10 mg	1.0 h	4 hours

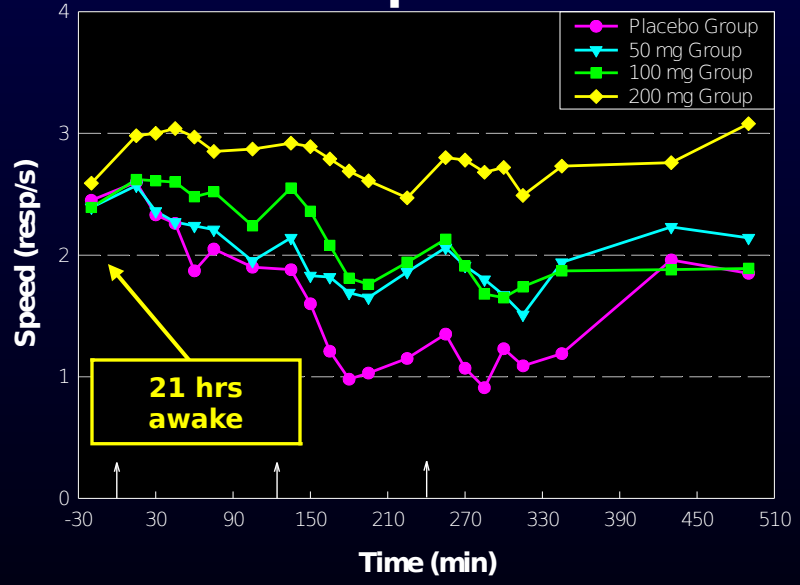
Ground testing required prior to operational use.

When no sleep is possible, consider the use of caffeine

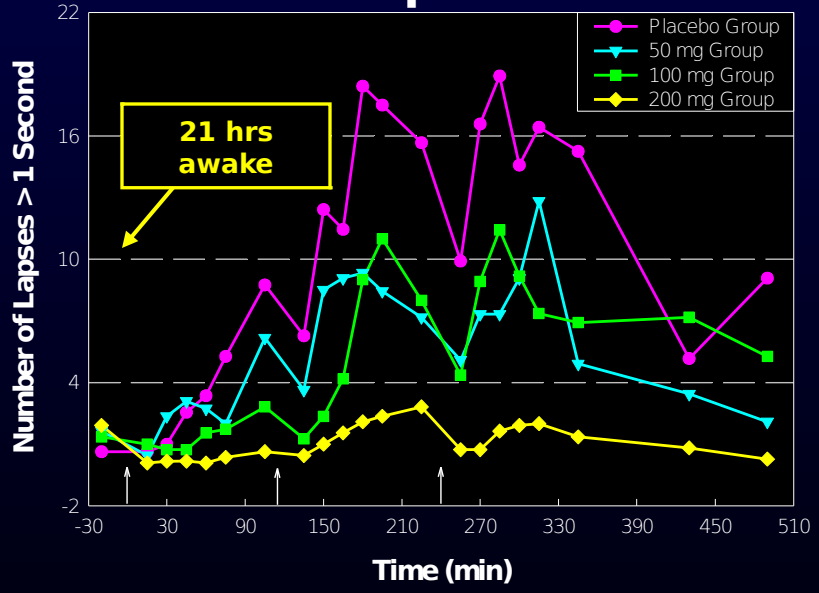
- When natural fatigue countermeasures are impossible, caffeine is an effective alternative.
- Studies have shown that caffeine significantly improves both alertness (measured by MWTs) and performance (measured by the PVT, etc.).
- Doses ranging from 200-600 mg are particularly effective in people who do not normally use caffeine.
  - 1 cup Maxwell House= 100 mg 1 Coke= 50 mg
  - 1 Starbucks Short= 250 mg 1 Mountain Dew= 55 mg
  - 1 Starbucks Tall= 375 mg 2 Anacin= 65 mg
  - 1 Starbucks Grande= 550 mg 2 Excedrin Xtra. Str.= 130 mg
  - 1 cup tea= 50 mg 1 Max. Str. NoDoze= 200 mg
- However, caffeine must be used judiciously.
  - It is best to take caffeine only right before you need it!

Caffeine can attenuate the impact of sleep deprivation

Psychomotor Vigilance Speed



Psychomotor Vigilance Lapses



The caffeine here was administered in the form of caffeine gum.

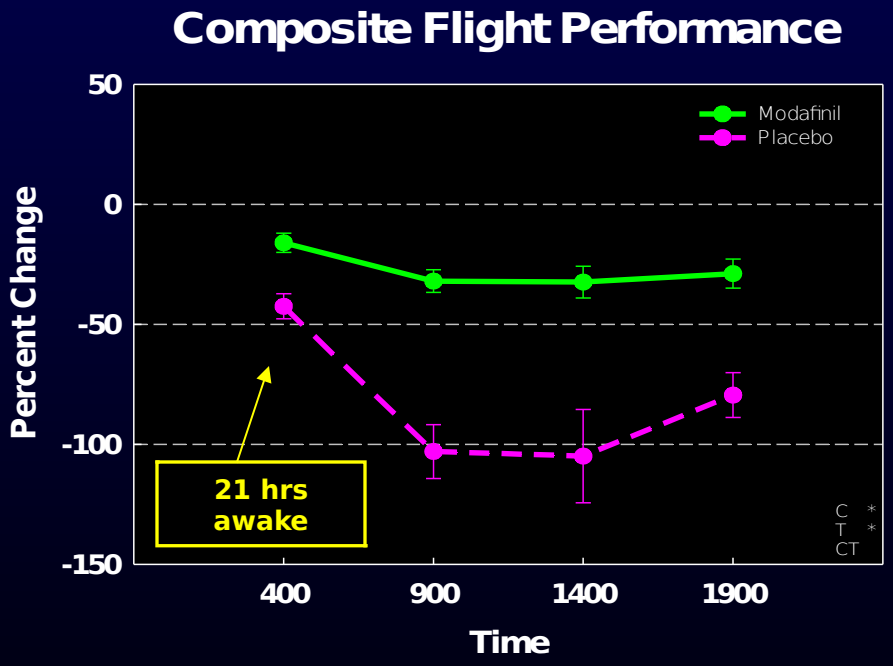
From Kamimori et al., 2002

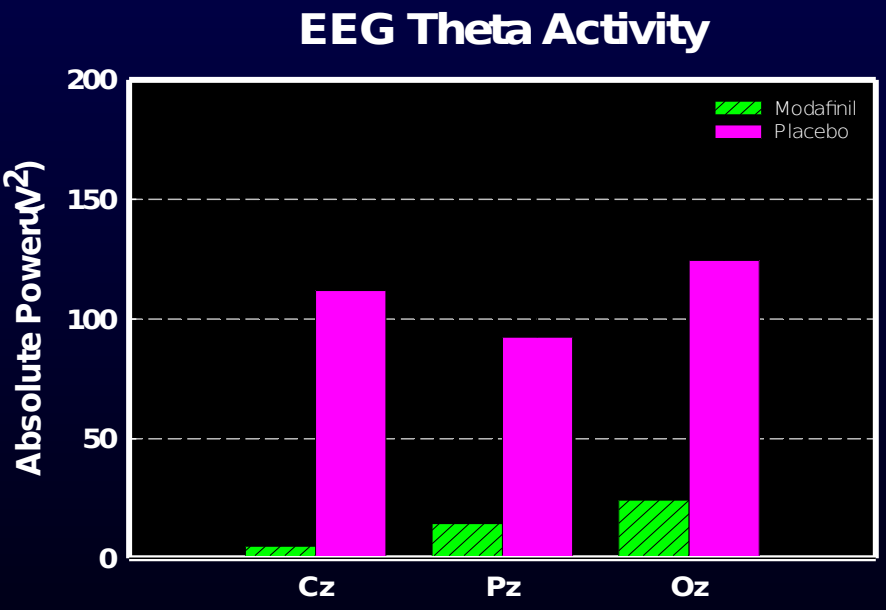
Of course, high doses of caffeine may produce side effects in some people

Modafinil may soon be a widespread alternative for military pilots

- **Modafinil (Provigil®) has been FDA approved for the treatment of narcolepsy.**
- **Studies of modafinil in normals have shown that it significantly improves flight performance, cognitive performance, and alertness.**
- **Doses ranging from 100-400 mg per day are effective *(currently, 100-200 mg every 8 hours is recommended).***
- **Studies are underway to further determine the safety and efficacy of modafinil in military pilots.**
- **At present, modafinil is not approved for use in the Army, (but it can be used in select Air Force bomber missions and in F-15E WSO's).**

Modafinil can sustain performance despite significant sleep loss





100 mg modafinil administered at 0000, 0500, and 1000

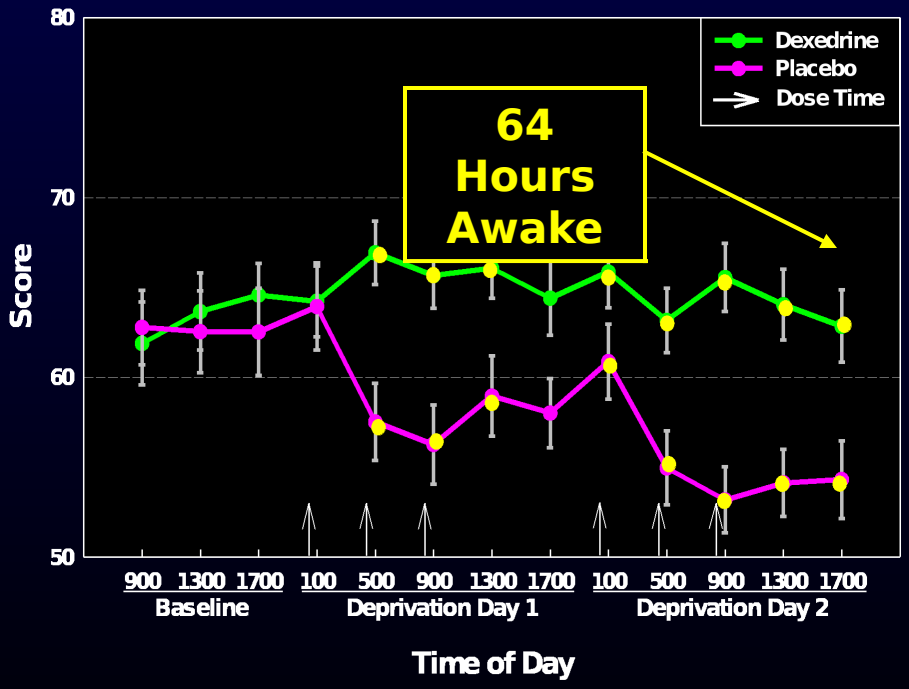
From *Caldwell, Caldwell, Smith, and Brown. (2004). Modafinil's effects on simulator performance and mood in pilots during 37 hours without sleep. Aviation, Space, and Environmental Medicine, 75(9):777-784*

Dexedrine® is an established fatigue countermeasure

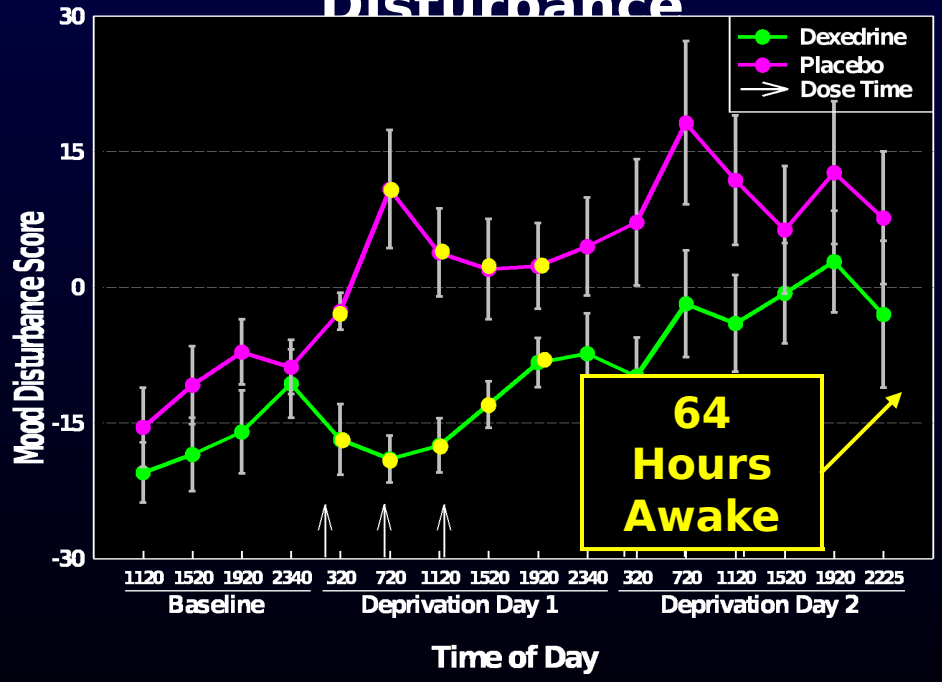
- Dextroamphetamine has been FDA approved for the treatment of narcolepsy and ADHD.
- Years of study show that amphetamines significantly improve the mood, cognitive performance, and alertness of fatigued people.
- Doses ranging from 5-20 mg, up to 60 mg per day, are safe *(currently, repeated 10 mg doses are recommended).*
- At present, Dexedrine® is approved for use in Army and Air Force combat aviation operations.

Dexedrine maintains wakefulness in sustained operations

Flight Performance



Subjective Mood Disturbance



From: *Caldwell, Smythe, LeDuc, and Caldwell. (2000). Efficacy of Dexedrine for maintaining aviator performance during 64 hours of sustained wakefulness: A simulator study. Aviation, Space, and Environmental Medicine, 71(1):7-18.*

Military guidance on stimulants

- **Army guidance—Stimulants, No Waiver Required:**

Medication	Dose	Daily Max	Half-life	Grounding
Caffeine (NoDoz®, Vivarin®)	100-200 mg	Not spec.	4.0- 6.0 h	Not applicable
Modafinil (Provigil®)	Not Authorized	na	na	Not applicable
Dextroamphetamine (Dexedrine®)	5 or 10 mg	30 mg	10.0-12.0 h	Not applicable

- **Air Force guidance—Go Pills, No Waiver Required:**

Medication	Dose	Daily Max	Half-life	Grounding
Caffeine (NoDoz®, Vivarin®)	100-200 mg	Not spec.	4.0- 6.0 h	Not applicable
Modafinil (Provigil®)**	200 mg	400 mg	10.0- 12.0 h	Not applicable
Dextroamphetamine (Dexedrine®)	5 or 10 mg	Not spec.	10.0- 12.0 h	Not applicable

Caffeine use (except in foods and beverages) must be authorized by Flight Surgeon.

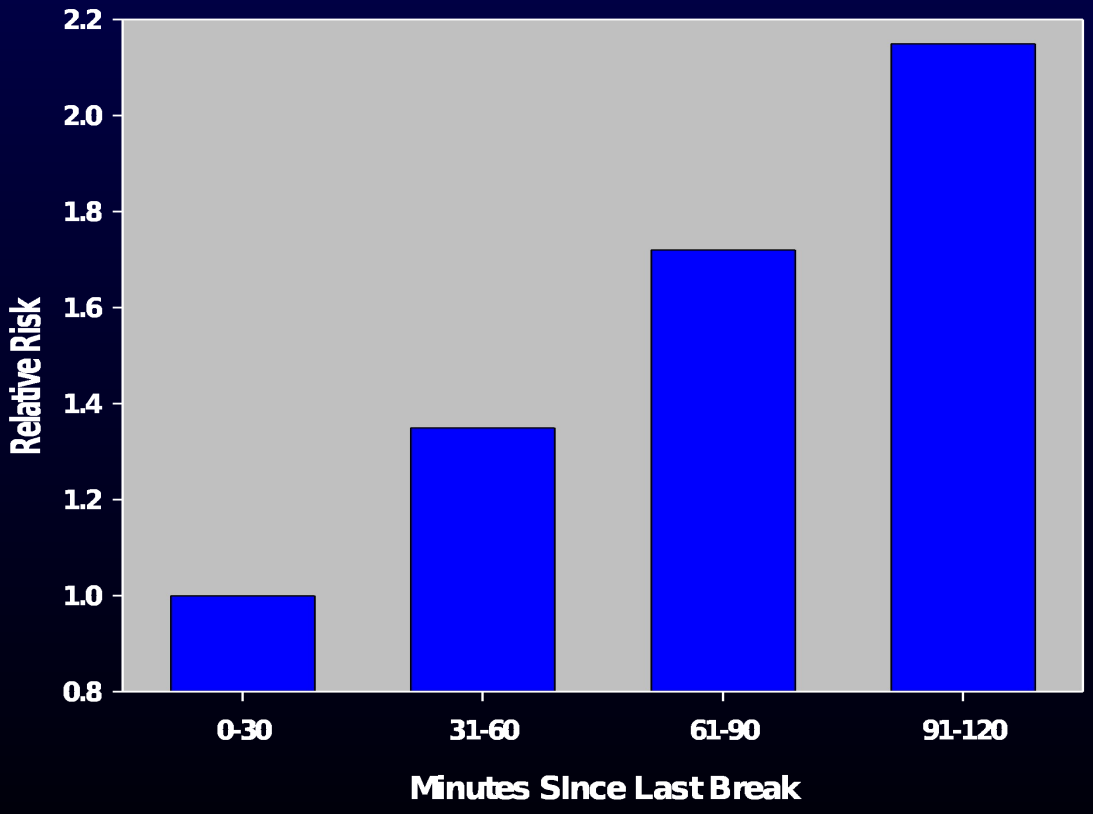
Dexedrine® use allowed only after ground testing.

These policies apply to Army aircrew and select Air Force fighter and bomber crews

Properly-spaced rest breaks can help sustain performance

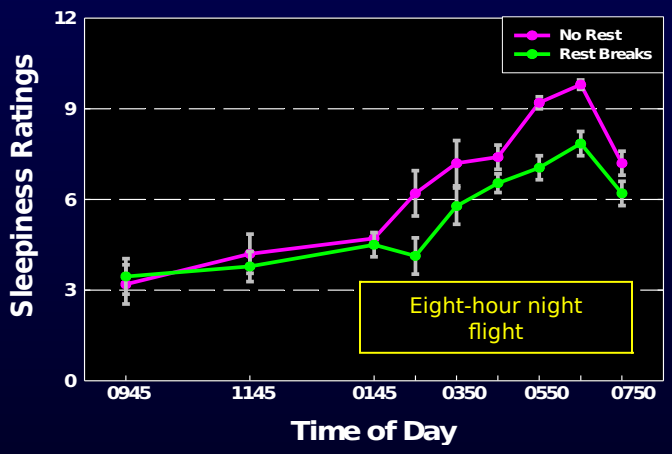
- Long bouts of work produce fatigue and boredom which can seriously impair performance.
  - Liberal rest breaks provide for physiological recovery, increased mental stimulation, and improved mood.
  - Studies have shown that work breaks improve productivity and reduce subjective sleepiness.
- Optimum schedules for breaks have not been determined.
- However, a break at least every 1-2 hours is recommended when possible.
- The more repetitious, boring, and tedious the task, the more frequently breaks should be scheduled.

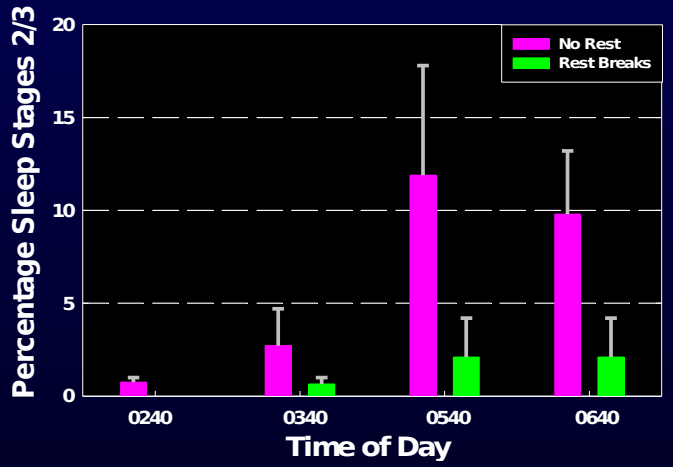
Breaks help reduce risk, particularly when working long hours

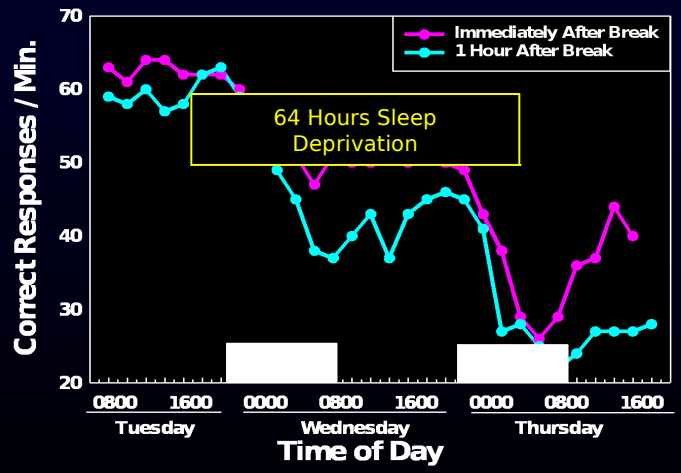


From: *Foldard and Tucker. (2003). Shift work, safety and productivity. Occupational Medicine. 53(2):95-101.*

Short breaks temporarily restore performance







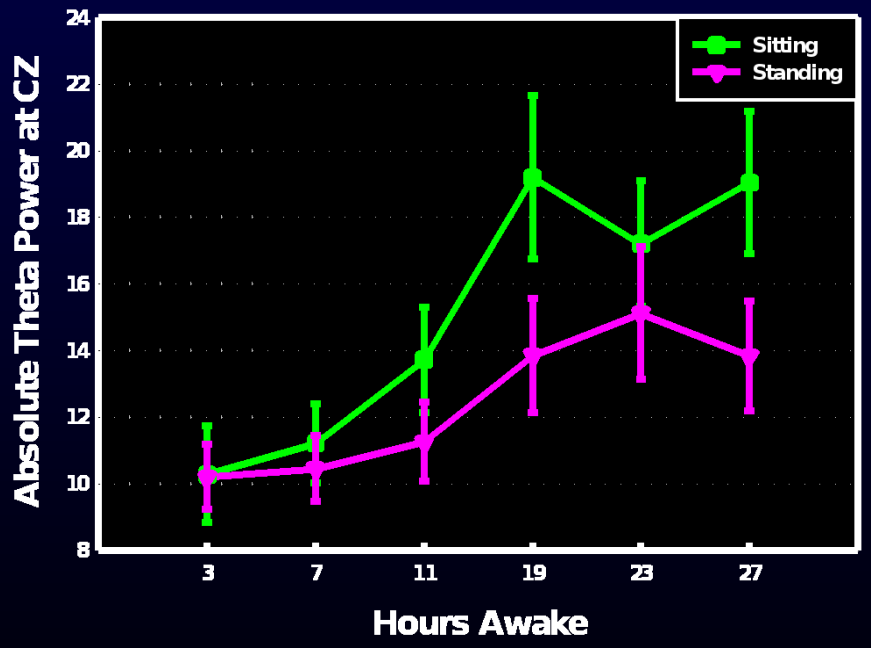
Pigeau et al., 1995; Neri , Oyung, Colletti, Mallis, Tam, Dinges. (2002). Controlled breaks as a fatigue countermeasure on the flight deck. Aviation, Space, and Environmental Medicine,

Body posture can influence the level of sleepiness

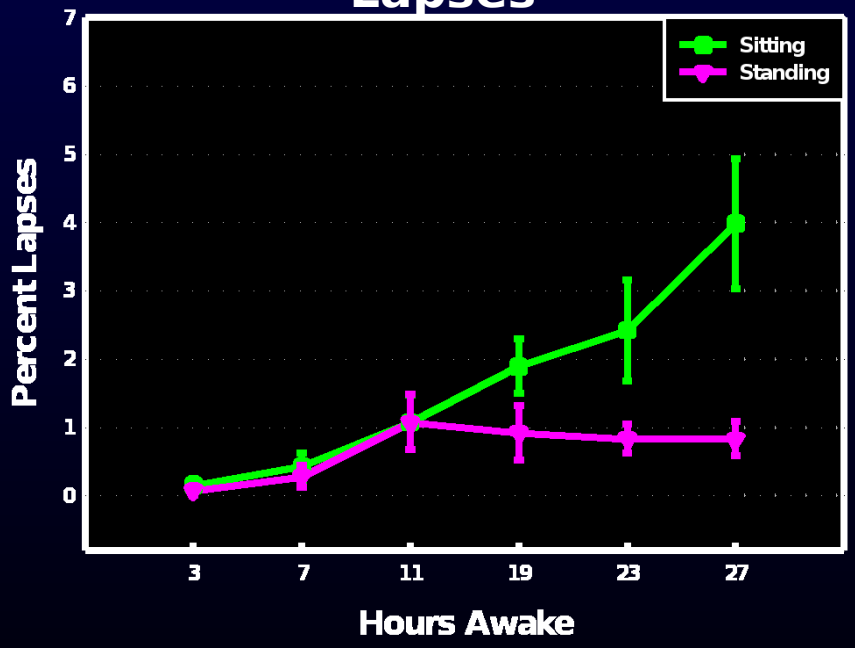
- In general, the more upright the body's position, the less sleepiness there will be.
  - Tilting people upright on a tilt-table causes higher-frequency brain activity than lying flat.
  - The less people are allowed to recline in their seats, the less they are able to sleep.
  - Narcolepsy patients report less sleepiness while standing than while sitting.
- Research shows that physiological alertness and performance in sleep-deprived people is better when standing than when sitting.

An upright posture attenuates slow-wave EEG and reduces attention lapses

Slow-wave Brain Activity



Psychomotor Vigilance Lapses



Caldwell, Prazinko, and Caldwell. (2003). Body posture affects electroencephalographic activity and psychomotor vigilance task performance in sleep-deprived subjects. *Clinical Neurophysiology*, 114(1):23-31.

Exercise, cold air, and music don't really help

- **Some research shows that exercise can slightly improve alertness.**
  - **However, the effect is short-lived (maybe 20 minutes) and probably leads to more fatigue later.**
  - **Frequent exercise breaks aren't feasible in most aviation operations.**
- **"Cold air to the face" has not been proven to stave off fatigue.**
- **Listening to a radio *slightly* improves reaction time and decreases subjective sleepiness.**
  - **However, there is no evidence that it improves driving or other types of performance.**

Physical fitness is not a safeguard against mental fatigue

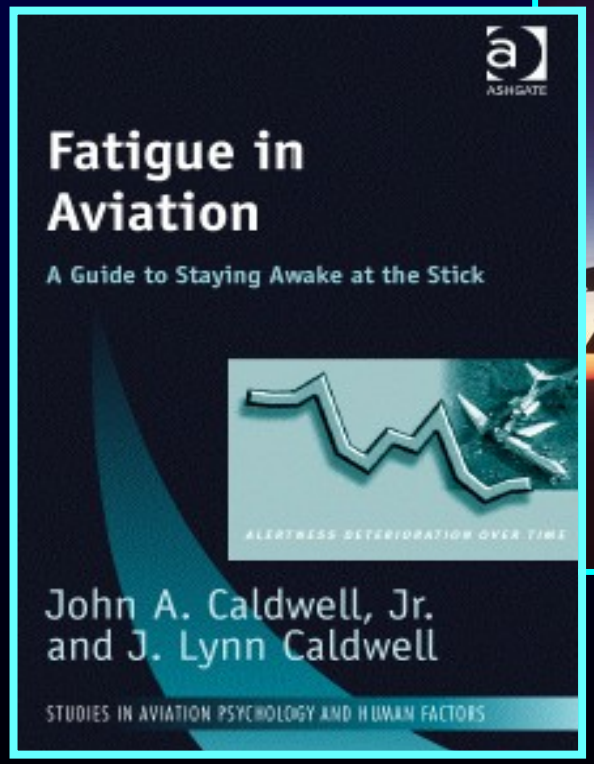
- The military has historically tried to decrease fatigue susceptibility by improving physical fitness.
- This strategy works well in jobs which require physical labor.
- However, it does not protect against mental fatigue.
  - One study showed fewer subjective complaints from night workers after physical training, but actual performance was not affected.
- Physical fitness may help you look better and live longer, but don’t depend on it to overcome fatigue!

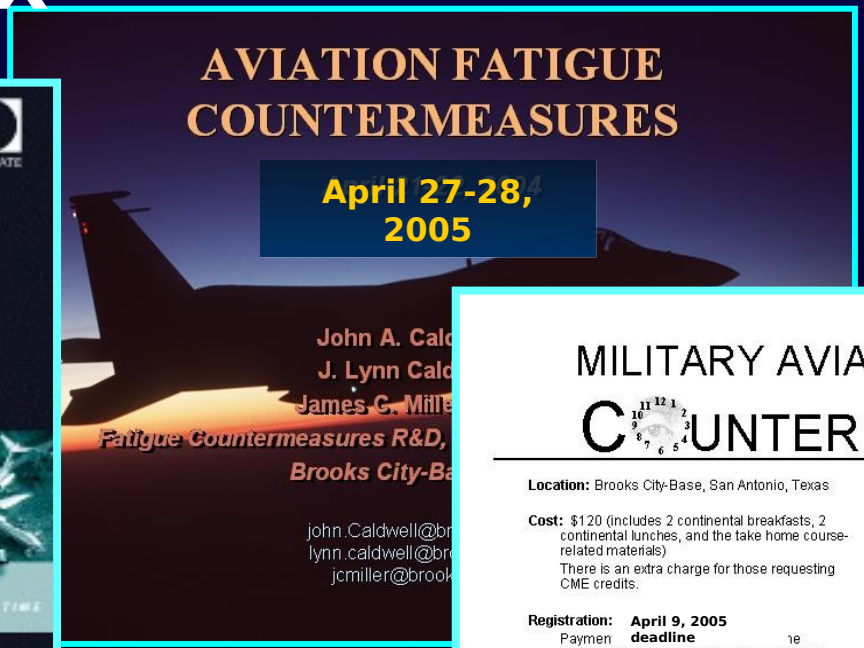
Summary and conclusions

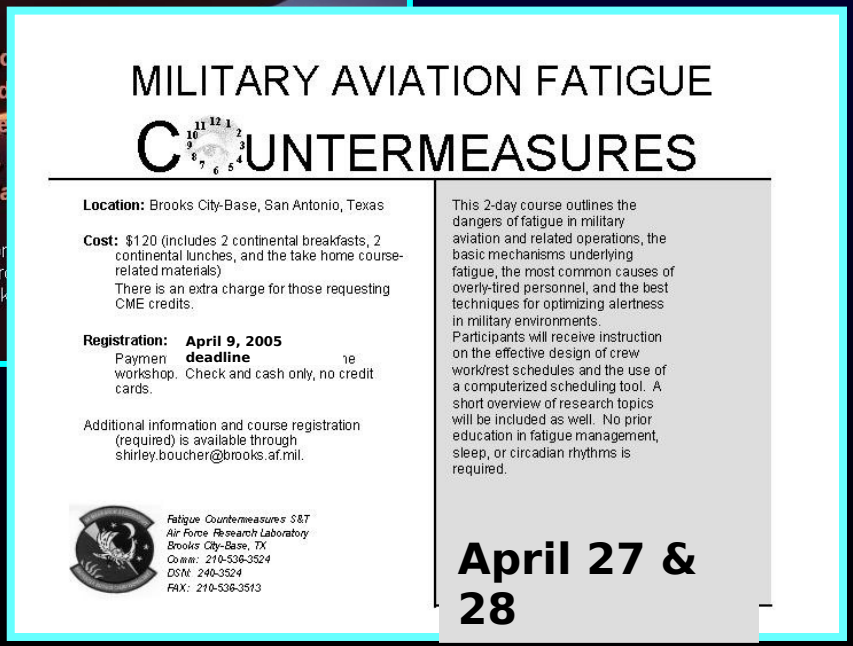
- Fatigue is a major contributor to accidents, lost productivity, and poor quality of life.
- As the operational tempo continues to increase, the potential for fatigue-related problems will only become more serious.
- However, safety, performance, and general operational readiness can be preserved by:
  - Adhering to good work-scheduling practices.
  - Implementing proven fatigue countermeasures.
  - Ensuring that off-duty personnel have sufficient sleep opportunities.
  - Making adequate daily sleep a top priority.
- Remember, sleep is a physical necessity--not a luxury, and there is NO substitute for SLEEP!

For more detailed information

- Get the book and attend the 2-day workshop at Brooks AFB in San Antonio, TX


ASHGATE
Fatigue in Aviation
A Guide to Staying Awake at the Stick
John A. Caldwell, Jr. and J. Lynn Caldwell
STUDIES IN AVIATION PSYCHOLOGY AND HUMAN FACTORS




MILITARY AVIATION FATIGUE
COUNTERMEASURES
Location: Brooks City-Base, San Antonio, Texas
Cost: $120 (includes 2 continental breakfasts, 2 continental lunches, and the take home course-related materials)
There is an extra charge for those requesting CME credits.
Registration: April 9, 2005 deadline
Paymen ne workshop. Check and cash only, no credit cards.
Additional information and course registration (required) is available through shirley.boucher@brooks.af.mil.
Fatigue Countermeasures S&T
Air Force Research Laboratory
Brooks City-Base, TX
Comm: 210-536-3524
DSN: 240-3524
FAX: 210-536-3513
This 2-day course outlines the dangers of fatigue in military aviation and related operations, the basic mechanisms underlying fatigue, the most common causes of overly-tired personnel, and the best techniques for optimizing alertness in military environments. Participants will receive instruction on the effective design of crew work/rest schedules and the use of a computerized scheduling tool. A short overview of research topics will be included as well. No prior education in fatigue management, sleep, or circadian rhythms is required.
April 27 & 28

Fatigue Countermeasures Program

State of the Art Fatigue Management for America's Air Force

For more information, contact:

Dr. John Caldwell at 210-536-8251 or john.caldwell@brooks.af.mil